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The 2015 Clean Water Rule's Impact on Oil and Gas Development in the Bakken Shale

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The 2015 Clean Water Rule's Impact on Oil and Gas Development in the Bakken Shale

by

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Abstract

The 2015 Clean Water Rule's Impact on Oil and Gas Development in the Bakken Shale

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The 2015 Clean Water Rule (CWR) amended the definition of aquatic resources under the federal jurisdiction of the Clean Water Act (CWA). Jurisdiction is re-asserted over a specified portion of aquatic resources legally designated as isolated. The "isolated waters" stipulations apply to the Prairie Pothole Region (PPR), a region recently threatened by heightened oil and gas activity associated with the economic productivity of the underlying Bakken shale. The architects of the CWR claim it does not dramatically expand the jurisdictional scope of the CWA. The Oil and Gas Industry refutes this notion claiming the expansionary nature of the CWR will dramatically increase indirect costs associated with the CWA Section 404 dredge and fill provisions, crippling production in select regions.

This study incorporates GIS spatial analysis with predictive modeling tools to determine the CWR's impact to oil and gas development in the Bakken Shale portion of the PPR. More specifically, this study estimates and characterizes the extent of geographically isolated waters in the study region, determines the scope of jurisdiction within the study region based upon the CWR's stipulations, and forecasts the economic impact to the oil and gas industry based upon the industry's development footprint from 2006-2014.

Results reaffirm the substantial amount of aquatic resources located within the study region. Furthermore, a significant portion of those resources will become jurisdictional under the new rule. However, the impacts to oil and gas industry are not expected to parallel the increase in jurisdiction. Development patterns over the last decade reveal an insignificant number of permanent impacts to wetlands associated with the development of 4,000 wells. Instead, the estimated increase in jurisdiction will increase the importance of incorporating environmental awareness measures into current operations to alleviate inevitable costs associated with delays, mitigation, and compensation, all while ensuring the industry's long-term sustainability.

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Chapter 1: Introduction

"Law likes to put things neatly in categories, nature is a bit messier" (Gardner, 2011). The environment supplies a limitless array of aquatic resources intertwined within the hydrological cycle. The protection of these vital resources forces a discretization based on feasibility and a limited understanding. The Clean Water Act (CWA) Section 404 regulations are a prime example of the divergence between law and science.

On August 29, 2015, the 2015 Clean Water Rule (CWR) was put into effect amending the definition of the aquatic resources (waters) under the federal jurisdiction of the CWA (statute). The administering agencies tout its passage as the next step towards eliminating the perpetual confusion regarding the regulatory reach of the statute. The experts responsible for fleshing out the details claim the rule will mitigate the slow, confusing and costly process of making a jurisdictional determination and assert federal protection over the aquatic resources deemed necessary to fulfill the CWA's purpose. Most notably, in addition to achieving those objectives, the agencies claim the rule does not dramatically expand the jurisdictional scope of the statute.

The CWR reverses a decade-long narrowing trend that eliminated a large portion of waters lacking an acceptable link to the hydrological cycle from jurisdictional contention. New qualifiers, based largely off the latest scientific understanding, reasserts jurisdiction over a specified portion of these aquatic resources formerly designated as legally isolated.

The "isolated waters" stipulations apply to the Prairie Pothole Region (PPR), a region historically absent of development aside from agriculture and only recently under the assumed threat of heightened oil and gas activity due to the economic productivity of the underlying Bakken shale formation. The Oil and Natural Gas (O&G) industry, a noted challenger to the CWR's legal status, proclaims the "expansionary"[1] nature of the CWR will dramatically increase indirect costs associated with the CWA Section 404 dredge and fill provisions producing a crippling effect. A greater share of projects unavoidably intersecting jurisdictional boundaries will increase in the number of activities requiring permits, delays in the timing of operations and an increase in restoration and mitigation requirements. The industry refutes the agencies' estimation of the resultant increase in jurisdiction as "grossly underestimated."[2] It has yet to be determined if these claims may be substantiated by analysis revealing the industry's unavoidable need to impact the aquatic resources in question.

THE SOURCE OF CONFLICT: THE STATUTE

The Federal Water Pollution Control Act of 1972, commonly known as the Clean Water Act (CWA), is a comprehensive program designed to regulate surface water pollution. The CWA establishes a legal framework to ensure federal protection for a designated set of water resources in the United States. It is the government's primary regulatory tool to protect wetlands. The CWA was enacted in principal to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." An attempt to attain this goal required the adoption of several permitting programs each designed to control a different type of pollution. One less obvious source of pollution is the discharge of "dredged and fill material." Dredged and fill material is commonly composed entirely of natural material, however, it has the potential to eliminate an aquatic resource entirely. To address this form of pollution Congress promulgated Section 404 of the CWA. Unfortunately, the CWA does not precisely define which waters are covered, what

[1] Independent Petroleum Association of America (IPAA), American Exploration & Production Council (AXPC), Western Energy Alliance (WEA), Comment to Proposed Rule, Page 3, November 14, 2014; http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OW-2011-0880-18864
[2] Id

activities are regulated, or what permitting standards are applied. It is up to the United States Environmental Protection Agency (EPA) and the United States Army Corps of Engineers (Corps), together known as the agencies, to develop the rules to provide these explicit answers.

"WATERS OF THE UNITED STATES"

The core policy of the CWA is laid out in Section 301: "it is illegal to discharge pollutants[3], except in compliance with the act, into navigable waters from any point source."[4] The language purveys an intention to protect the aquatic resources associated with the term "navigable waters," or as interpreted by the Act, "waters of the United States (WOUS), including the territorial seas."[5] "Territorial seas" is explicitly defined as coastal waters up to three miles from shore. In contrast, the WOUS segment is given no such advantage except for the congressional expectation of broad interpretation. The governing agencies, through a series of rulemakings, have established regulation interpreting the aquatic resources to be regulated as WOUS. 33 CFR 328.3(a) defines WOUS to not only include "navigable waters" in the traditional and literal sense but also several other categories of aquatic resources (Figure 1).

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3 A wide variety of pollutants fall under the act's scope: "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, discarded equipment, rock, sand, dirt, and industrial, municipal, and agricultural waste." (33 U.S.C. § 1362(6), CWA § 502(6)).

4 A point source is defined as "any discernable, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling rock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged." (33 U.S.C. § 1362(14), CWA § 502(14)).

5 33 U.S.C. § 1362(14), CWA § 502(7).

Definition of "***waters of the United States***":

1) All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
2) All interstate waters including interstate wetlands;
3) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:
    a. Which are or could be used by interstate or foreign travelers for recreational or other purposes; or
    b. From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
    c. Which are used or could be used for industrial purposes by industries in interstate commerce;
4) All impoundments of waters otherwise defined as waters of the United States under this definition;
5) Tributaries of waters identified in paragraphs (s)(1) through (4) of this section;
6) The territorial sea;
7) Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (s)(1) through (6) of this section; waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR 423.11(m) which also meet the criteria of this definition) are not waters of the United States.

Waters of the United States do not include prior converted cropland. Notwithstanding the determination of an area's status as prior converted cropland by any other federal agency, for the purposes of the Clean Water Act, the final authority regarding Clean Water Act jurisdiction remains with EPA.

Figure 1. The definition of "Waters of the U.S." before the 2008 Rapanos Guidance (33 CFR 328.3(a)(2007)).

SUPREME COURT INTERPRETATIONS

The initial regulatory interpretation retained the inherent elasticity of the Act. The Corps required permits for activities involving discharges into a limitless range of waters. Regulatory action was very difficult to predict, stemming from the nearly impossible task of drawing lines where land ceases to be wet and becomes dry. As economic expansion and development progressed, the act of making a jurisdictional determination inevitably became a difficult, hotly debated, and ongoing task.

Three challenges in opposition to agency determinations made it all the way to the Supreme Court. The ruling opinions in these cases provided benchmarks for making jurisdictional determinations across the country as well as the rationale behind new regulation and subsequent judgments. In addition, they highlighted some of the current regulation's main ambiguities and sources of conflict.

In 1986, in the aftermath of a Supreme Court ruling in favor of the agencies' assertion of jurisdiction over wetlands adjacent to traditional navigable waterways (TNW), the Corps modified its regulations in an attempt to clarify what is considered jurisdictional under section 328.3(a)(3) regarding such waters at the opposite extreme of adjacency: "isolated waters." The preamble to the new regulation stated "isolated waters" would be regulated if their use, degradation, or destruction could affect interstate commerce. In what would become known as the Migratory Bird Rule (MBR), the Corps proclaimed it would regulate activities in isolated waters that are or would be used as habitat by migratory birds that cross state lines.

In 2001, in Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers (SWANCC), the Supreme Court would rule on the legitimacy of the MBR as a reasonable interpretation of the CWA. The Corps' argument was based on two principles. Migratory birds represented a biological connection of sort consistent with the CWA's goal of protecting the biological integrity of the nation's waters. In addition, it was well established that the jurisdictional scope of the CWA extended as far as the Commerce Clause afforded. However, in a setback for the federal authority to regulate such waters, the Supreme Court ruled a particular set of intrastate isolated ponds were not intended for reach by the CWA due to the lack of substantial evidence supporting the notion that they are “inseparably bound up with WOUS.” The Court concluded jurisdiction did not extend to isolated waters that do not have, by legal definition, a “significant nexus” to traditional navigable waters.

In 2006, the Supreme Court ruled on another discrepancy in CWA jurisdiction for waters in between the two extremes of adjacency and isolation. In particular, the case focused on wetlands adjacent to non-navigable tributaries of TNWs. It is the latest higher ruling on the meaning of the term WOUS and the result that cemented the current state of complexity and confusion regarding the CWA’s jurisdictional limits. This time, no majority opinion was reached. Justice Scalia, writing on behalf of three others, held that “navigable waters” and thus WOUS refers only to circumstances where waters are continuously flowing and have a continuous surface water connection to TNWs.[6] Four other dissenting Justices maintained that wetlands should be jurisdictional regardless of the “permanence” of connection to TNWs, in that, even a distant hydrological connection can provide some important downstream functions. Justice Kennedy, standing alone, took the phrase “significant nexus” from the SWANCC opinion and developed a standard for evaluating whether or not an aquatic resource merits the status of a jurisdictional water. According to Justice Kennedy:

> “Wetlands possess the requisite nexus, and thus come within the statutory phrase ‘navigable waters,’ if the wetlands, either alone or in combination with similarly situated lands in the region, significantly affect the chemical, physical, and biological integrity of waters more readily understood as navigable.”[7]

In contrast, if a particular wetland’s effects on TNWs are “speculative or insubstantial,”[8] they fall outside the statutory realm.

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[6] *U.S. v. Rapanos*, 547 U.S. 715, 742 (2006).
[7] 547 U.S. at 780
[8] 547 U.S. at 780

THE CURRENT STANDARD

The lack of a majority ruling from *Rapanos* left the interpretation of CWA jurisdiction in flux. Regulated entities were left to interpret multiple approaches in order to produce new guidance, a scenario largely prohibitive of a clear and concise response. Justice Kennedy's opinion essentially emerged as the most influential. As it turns out, it also happened to be the most ambiguous, and when implemented, could assert jurisdiction over the most features and stir more conflict.

In 2007, the agencies issued the *Rapanos* Guidance. Aquatic resources were placed into three categories: those over which jurisdiction would definitely be asserted, those over which they generally would not, and those they probably would if a significant nexus to a TNW could be demonstrated. Under all circumstances the agencies would assert jurisdiction over the following:

- TNWs and their adjacent wetlands;
- Relatively permanent[9] non-navigable tributaries of TNWs;
- Wetlands that directly abut the above non-navigable tributaries.

The limited set of waters the agencies would generally defer jurisdiction over include:

- Swales and gullies with low volume or flows of short or infrequent duration;
- Upland ditches with intermittent flows that drain only uplands.

The significant nexus test would be applied to waters fitting in-between these two categories:

- Non-navigable tributaries that are not relatively permanent;
- Wetlands adjacent to non-navigable tributaries that are not relatively permanent; and

[9] Relatively permanent was interpreted as those waters typically flowing year round or have continuous flow at least seasonally (3 months).

- Wetlands adjacent to but that do not directly abut a relatively permanent non-navigable tributary.

The significant nexus analysis would determine the fate of waters not encompassed by the bright line boundaries at the more understood extremes of the connectivity continuum. The term "nexus" at best describes a multidimensional association that is difficult to comprehend. It prevents the need to delineate boundaries that would only ensnare a portion of the waters necessary for the CWA to meet its intention. Instead, the test is flexible enough to be supported by a range of factual and observable evidence that is more than "speculative and insubstantial."[10]

REGULATORY IMPACT

The immediate impact of the *Rapanos* Guidance provided an overall bleak outlook for a large portion of the country's aquatic resources. Individual Corps districts interpreted key terms differently to not only make tough jurisdictional calls, but make them efficiently. These terms include "adjacent," "tributary," and "significant nexus." The Association of State Wetland Managers (ASWM) predicted the level of federal oversight based upon different interpretations of the key terms. In one scenario the agencies make an interpretation allowing the regulation of TNWs, "tributaries," and "adjacent" wetlands. Under this approach, the ASWM estimated the total amount of regulated wetlands would likely only encompass 40-60% of all wetlands depending upon how broadly "tributary"

[10] 547 U.S. at 780

and "adjacent" are interpreted (Kusler, 2004).[11] Under the scenario allowing the regulation of TNWs, "tributaries," "adjacent" wetlands and those with a "significant nexus" to TNWs, total jurisdictional coverage expands to 80-90% of all wetlands (Kusler, 2004). However, this estimate assumes a broad interpretation of "significant nexus" allowing various methods by which isolated waters may demonstrate a nexus.

The net effect of the *Rapanos* Guidance is the dramatic reduction in the level of regulation over isolated waters, including isolated wetlands, out of necessity to support regulatory program productivity. Generally, jurisdictional determinations disregarded wetlands that were isolated by rule. According to most regional conditions, isolated waters lack a direct or indirect physical surface hydrologic connection to a downstream water of the U.S., and where the water is not neighboring, bordering, or contiguous to such waters.

Conversely, the *Rapanos* Guidance strengthened the need to properly identify isolated wetlands. Language in the *Rapanos* opinions provide support for asserting jurisdiction over isolated wetlands. According to Justice Kennedy's standard, a wetland not meeting the interpretation of "adjacent" would need some sort of qualifying connection, which he observed does not require a physical hydrological connection for the mere absence of a hydrological connection could create a significant nexus through the retention of floodwaters and pollution.

[11] Kusler, J. 2004. The SWANCC Decision: State Regulation of Wetlands to Fill the Gap. Association of State Wetland Managers, Berne, NY. www.aswm.org/fwp/swancc/aswm-int.pdf.

“ISOLATED WATERS”

The Supreme Court’s legal construct “isolated wetland” implies total functional isolation. However, many attest “isolated wetland” is a relative term that could be used to describe geographical, hydrological, or ecological separation. The term “isolated” denotes an object completely separate from and lacking interaction with other objects (Leibowitz, 2003). When incorporated into “isolated wetland” or “isolated water,” the meaning loosely categorizes waters somehow separated from downstream TNWs. It is neither relevant from an ecological perspective nor concise enough for regulatory purposes.

Armed with the need to properly identify and categorize “isolated wetlands,” policy makers used the Supreme Court rulings as an opportunity to review the current scientific understanding of isolated wetlands, particularly, the ways in which isolated wetlands and their functions contribute to the physical, chemical, and biological integrity of waters of the U.S. Their intended purpose: to demonstrate the effect of seclusion is not as pronounced as the term “isolated” suggests, or to put plainly, geographic isolation does not equate functional isolation.

Most wetland scientists would agree there is no such thing as an ecologically “isolated” wetland. Hydrologic and biotic connectivity are not discrete characteristics. They vary in their magnitude and spatial-temporal occurrence. An attempt to use such criteria to classify wetlands as isolated or non-isolated can be difficult because the degree of isolation is difficult to assess (Leibowitz, 2003). “Isolation” is best described as occurring on a continuum between completely isolated and connected (Leibowitz, 2003). From a regulatory standpoint, isolated wetlands have been shown to display hydrologic connectivity. One established process is through groundwater flow (Winter and LaBaugh, 2003). Other empirical evidence has established intermittent surface-water connections among isolated wetlands during high flow events. For example, in the Prairie Pothole Region (PPR) Leibowitz and Vining (2003) found temporary surface-water connections between isolated wetlands during high flow events while Stichling and Blackwell (1957) found similar connections between isolated wetlands and downstream waters of the U.S.

In response to these findings, Snodgrass et al (1996) proposed a definition for isolated wetlands as "depression wetlands that under average surface-water levels are not connected to other aquatic habitats by surface waters." Tiner (2003), recognizing both the need to add clarity to their classification and the inherent difficulty in discretizing isolated wetlands based on hydrological and ecological connectivity, coined the term "geographically isolated wetlands," wetlands completely surrounded by upland. The term allows for the discretization of isolated wetlands based on geographical terms, eliminating the variability and inherent difficulty in categorizing ambiguous hydrological or ecological relationships.

THE 2015 CLEAN WATER RULE

On August 28th 2015, the 2015 Clean Water Rule (CWR) amending the definition of WOUS granted federal protection under the CWA came into effect.[12] The rule set out to increase CWA program predictability and consistency by clarifying the scope of WOTUS.

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[12] 40 CFR Parts 110, 112, 116, 117, 122, 230, 232, 300, 302 and 401, Federal Register No. 2015-13435, 2015; http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OW-2011-0880-20862

To do so, the agencies set out to reduce the dependence upon case-specific jurisdictional determinations by turning to the utility of bright line boundaries, explicit qualifiers and exceptional circumstances. The result, the agencies claim, is an overall reduction in the scope of jurisdiction in comparison to existing regulation.

The CWR's interpretation of the CWA and technical basis is said to have been derived from peer-reviewed science, "particularly as that science informs the determinations as to which waters have a significant nexus with TNWs."[13] In January of 2015, the EPA published a technical review of scientific literature titled "Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence" (The Science Report). The science report synthesized all available scientific literature on the connectivity to and mechanisms by which various types of waters, either alone or in combination, have a downstream chemical, biological, or physical connection to TNWs (USEPA, 2015). The following conclusions were particularly noteworthy in supporting the CWR's assertion of jurisdiction:

- Significant hydrological connections occur on a continuum from highly connected to highly isolated;
- A physical hydrological connection is not a prerequisite for a significant influence to downstream waters;
- The critical contribution of upstream waters to the chemical, physical, and biological integrity of downstream waters results from the accumulative contribution of similar waters in the same watershed and in the context of their functions considered over time; and

[13] Id

- Non-floodplain wetlands and open waters provide many functions that benefit downstream water quality and ecological integrity.

Armed with scientific support and Supreme Court precedent eight types of jurisdictional waters were identified (Figure 2). They are organized into three categories: waters that are jurisdictional by rule in all instances, waters that are jurisdictional as defined, and a "narrowed" category of waters subject to case-specific jurisdictional analysis (Figure 1).

1. **<u>Jurisdictional By Rule in all cases</u>**
   I. **Traditional Navigable Waters**
   II. **Interstate Waters**
   III. **Territorial Seas**
   IV. **Impoundments of jurisdictional waters**
2. **<u>Jurisdictional as Defined</u>**
   I. **Tributaries**
      i. Qualifier - Presence of bed and bank and an indicator of an Ordinary High Water Mark (OHWM).
   II. **Adjacent Waters –**
      i. Qualifier - Within 100 feet of an OHWM, or waters whole or in part in the 100-year floodplain that are within 1,500 feet of an OHWM
3. **<u>Case Specific Analysis</u>**
   I. **Similarly Situated Waters**
      i. Qualifier - prairie potholes, Carolina Bays, pocosins, vernal pools, and coastal prairie wetlands
   II. **Other Case Specific Waters**
      i. Qualifier - Waters within a 100-year floodplain (beyond 1,500') and waters within 4,000 feet of an OHWM

Figure 2. Eight categories of WOUS identified by the CWR.

The third category established the limits under which a significant nexus analysis may be conducted, the primary factor in reducing the broad extent of waters subject to individual review. Specific aspects of the significant nexus standard were interpreted including: which waters to specifically evaluate in combination; the explicit functions provided by such waters for evaluation; and when it can be determined such waters have a significant effect.[14] The two exclusive provisions apply to those waters determined to be "similarly situated in the region" and those that do not otherwise meet the definition of adjacency but may be located within a distance evaluated in past jurisdictional determinations as having a significant connection to and effect on TNWs.[15]

ESTIMATED CHANGE IN JURISDICTIONAL EXTENT

The critical issue with any change in regulation is its impact on the regulated community, particularly, the extent to which the assertion of CWA jurisdiction may change as a result of this rule. The agencies anticipate the rule will cause more jurisdictional waters to fall out of jurisdiction than non-jurisdictional waters coming under jurisdiction. This may hold true for the scope of waters historically protected under the CWA, however, it does not seem plausible when considering recent regulatory practice in light of the aforementioned *Rapanos* Guidance.

As part of their economic analysis of the proposed rule, the agencies estimated the potential increase in jurisdiction by reviewing negative jurisdictional determinations (JDs). The greatest change was expected for waters categorically defined as "other waters."[16]

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[14] Functions to be considered for the purposes of a significant nexus determination include: sediment trapping, nutrient recycling, pollutant trapping, transformation, retention and attenuation of floodwaters. If a water, either alone or in combination with similarly situated waters, performs just one function, and that function has a significant impact on the integrity of a TNW, that water would have a significant nexus.

[15] "Similarly situated" is interpreted as all waters that function alike and are located sufficiently close to measure their downstream effects on a TNW in aggregation. "In the region" applies to a single watershed that drains to the nearest TNW.

[16] "Other waters" is used by the Corps to represent intrastate, non-navigable waters; including wetlands, lakes, ponds, streams, and ditches, that lack a direct surface connection to other waterways. The agencies assumed all records of negative determinations for streams and adjacent wetlands would be jurisdictional under the new rule.

Results produced a projected increase in positive JDs for these waters by 34.5 percent.[17] Based on the proportion "other water" records in the entire study sample, the relative contribution to the overall change in jurisdictional waters was estimated at 2.84 percent. To illustrate another possible scenario, the agencies doubled the number the number of negative JDs for "other waters" to account for landowners and/or project sponsors who assumed these waters to be non-jurisdictional during the study period. Under this assumption, the contribution climbs to a 4.65 percent increase in positive jurisdictional determinations.

Twenty-one percent of the records for "other waters" were located within the regions identified as "similarly situated" waters. As such, their jurisdictional status would require a case-specific analysis for a significant nexus. Using unspecified measures of density and proximity to the tributary system of a TNW, the agencies determined 15.7 percent of these "similarly situated" waters would become jurisdictional, a rather low number when considering the qualifying functions available for evaluation.

THE PRAIRIE POTHOLE REGION

Isolated wetlands are common features in many parts of the United States, in some cases the predominant aquatic resource. Tiner (2003) analyzed existing digital data to predict the extent of isolated wetlands in 72 study areas with results, although variable, highlighting some significant occurrences.[18] Eight study areas had more than half of their wetland area designated as isolated, while 24 others had 20-50 percent of their wetland

[17] This estimate was summed from a 17.1 percent increase due to the adjacency provision, a 15.7 percent increase due to the "similarly situated" provision, and a 1.7 percent increase due to the "other case specific waters" provision.

[18] Although the study intended to show examples of the extent of isolated wetlands in the United States, the study did not produce a statistically significant estimate of isolated wetlands throughout the nation.

area in this category. In addition, 43 sites had more than 50 percent of the total number of wetlands designated as isolated.

One such region predominated by isolated wetlands is the Prairie Pothole Region (PPR) (Figure 3). The PPR is simply characterized as a landscape of glacially formed wetlands occurring as a series of depressions that lack a natural, permanent hydrological outlet (Dahl, 2014) (Figure 4). Prairie potholes occur in the central U.S. from central Iowa through western Minnesota, eastern South Dakota, North Dakota and Canada encompassing an area of about 150,930 mi^2 (Dahl, 2014).

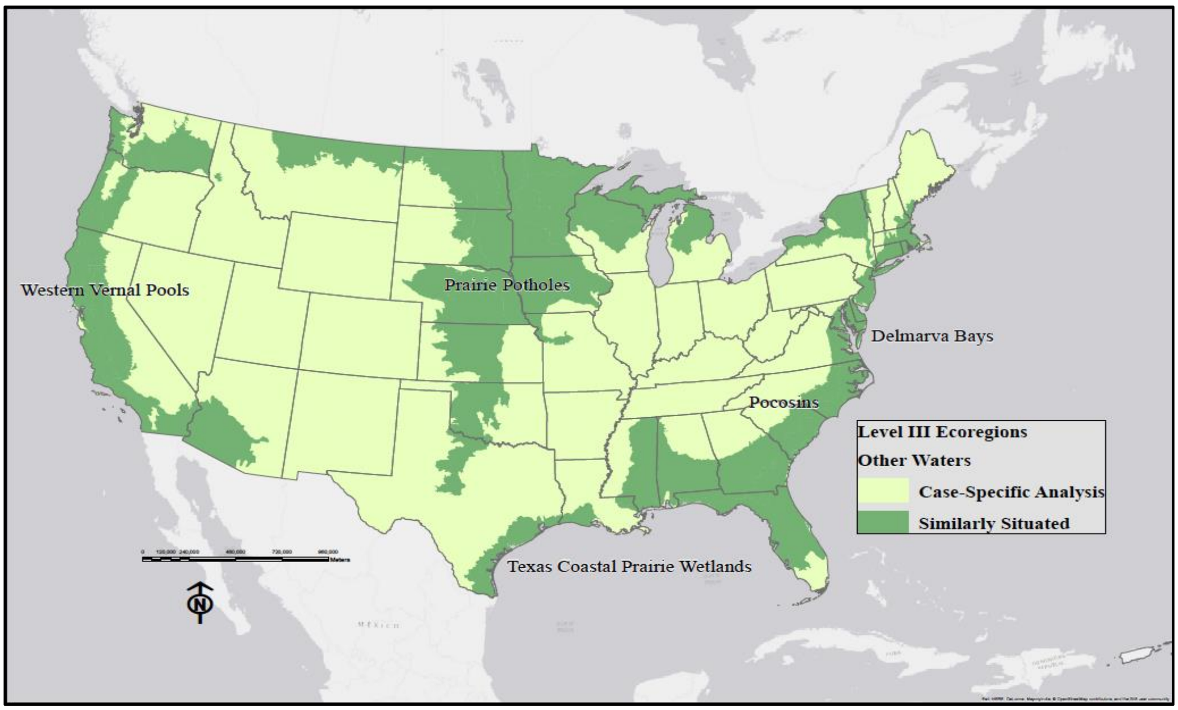

Figure 3. Level III Ecoregions depicting the five categories of similarly situated waters.

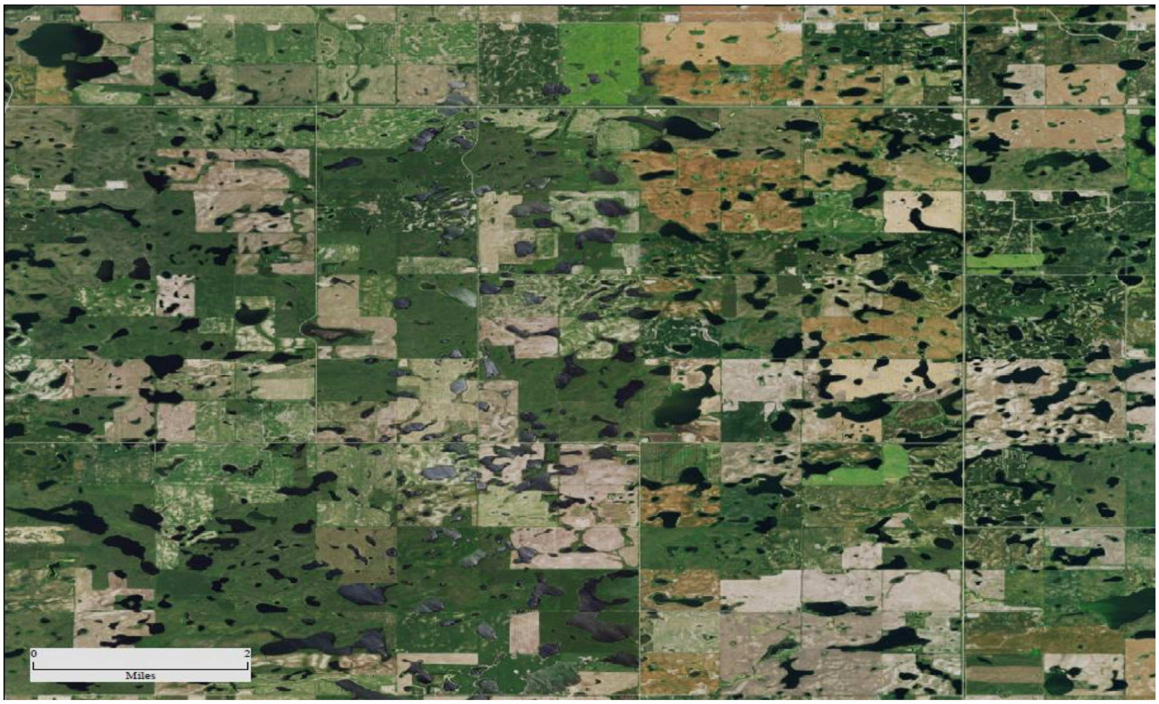

Figure 4. NAIP Aerial imagery (2014) depicting a landscape with a high density of prairie pothole wetlands

Tiner (2003) evaluated two PPR study sites. Of the area mapped as wetlands, 49-98 percent were considered isolated with the higher percentage attributed to a lack of streams in the study area. Of the number of wetlands mapped, 93-97 percent were predicted as isolated revealing a discrepancy in size between isolated and non-isolated wetlands in the PPR.

Dahl (2014) conducted a more focused study by examining the recent trend in wetland extent and habitat type throughout the PPR. An estimated extent of 6,427,350 acres of wetlands occurred within the entire PPR as of 2009, representing approximately 7 percent of the region’s total surface area. Eighty eight percent of all wetland basins in the

PPR were determined to be geospatially isolated.[19] By area, wetlands were found to be most common in North Dakota, making up approximately 9 percent (2.8 million acres) of the surface area in the PPR region of the state. Dahl (2014) also confirmed spatial variability among PPR wetland density.[20] Maximum wetland density exists in North Dakota with 148 basins per mi^2, with an average of 30 features per mi^2 (Dahl, 2014).

THE BAKKEN SHALE

Historically, the primary land use in the PPR has been agriculture. Drainage for agricultural production represented a primary factor affecting wetland trend changes, accounting for 95 percent of losses between 1997 and 2009 (Dahl, 2014). Forty-nine percent of all wetlands lost between 1997 and 2009 were isolated according to Dahl's (2014) geospatial model.

A more recent threat to PPR wetlands comes from another form of development. Two eco-regions within the PPR are partially underlain by the Bakken shale (Figure 5).

[19] Dahl (2014) developed a geospatial data model to identify wetlands not connected to or within a 100 ft. buffer distance of navigable water (rivers, streams, wetland complexes and permanent lakes).

[20] Density was calculated by tabulating the number of individual wetlands features per square mile.

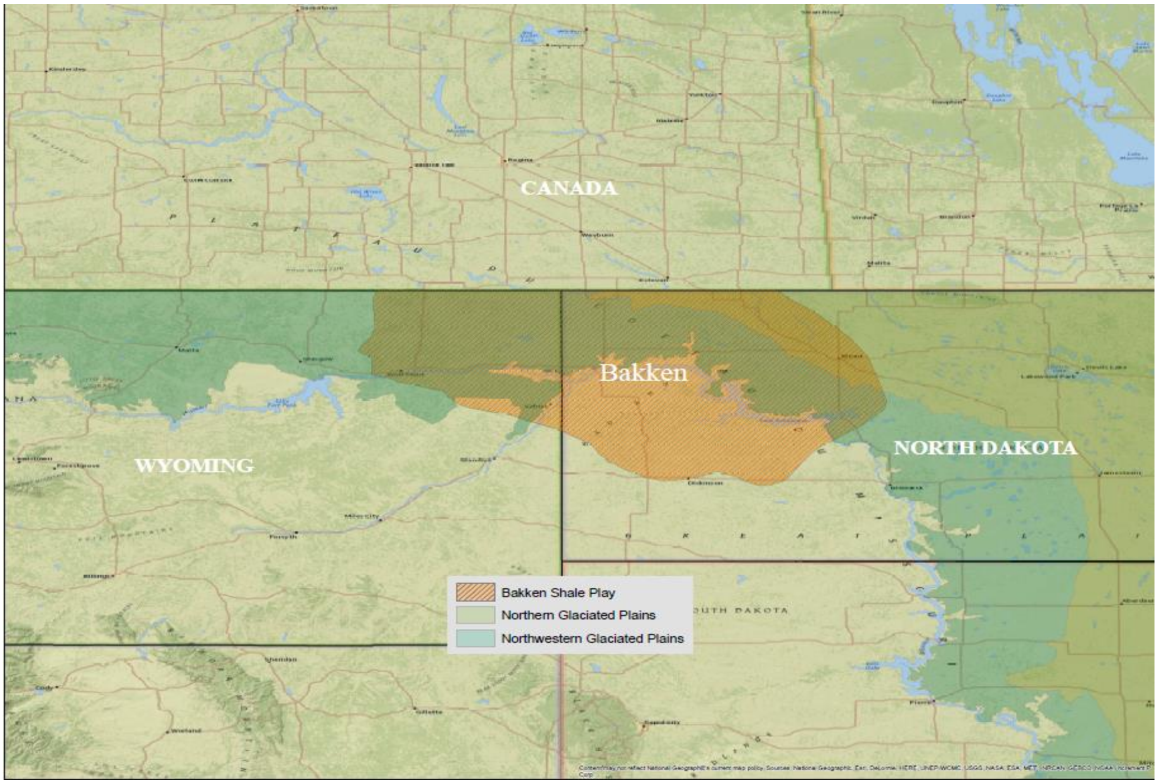

Figure 5. The extent of the Bakken shale formation relative to two eco-regions of the prairie pothole region.

Well data from the North Dakota Dept. of Mineral Resources (NDDMR) indicates O&G E&P in the Bakken dates back as far as 1950. However, the implementation of horizontal drilling coupled with the rock cracking technique dubbed hydraulic fracturing has made Bakken production economic on a much larger scale. The Bakken has been developed intensively since the start of the U.S. “fracking boom” of the last decade. The 2015 September Drilling Productivity Report issued by the Energy Information Agency (EIA) reports oil production within the Bakken shale increased from less than 200,000 barrels of oil per day (BPD) to roughly 1,200,000 BPD from 2007 to 2015 (Figure 6).

Accordingly, the Bakken is the third most prolific shale play behind the Eagle Ford shale and Permian basin respectively.

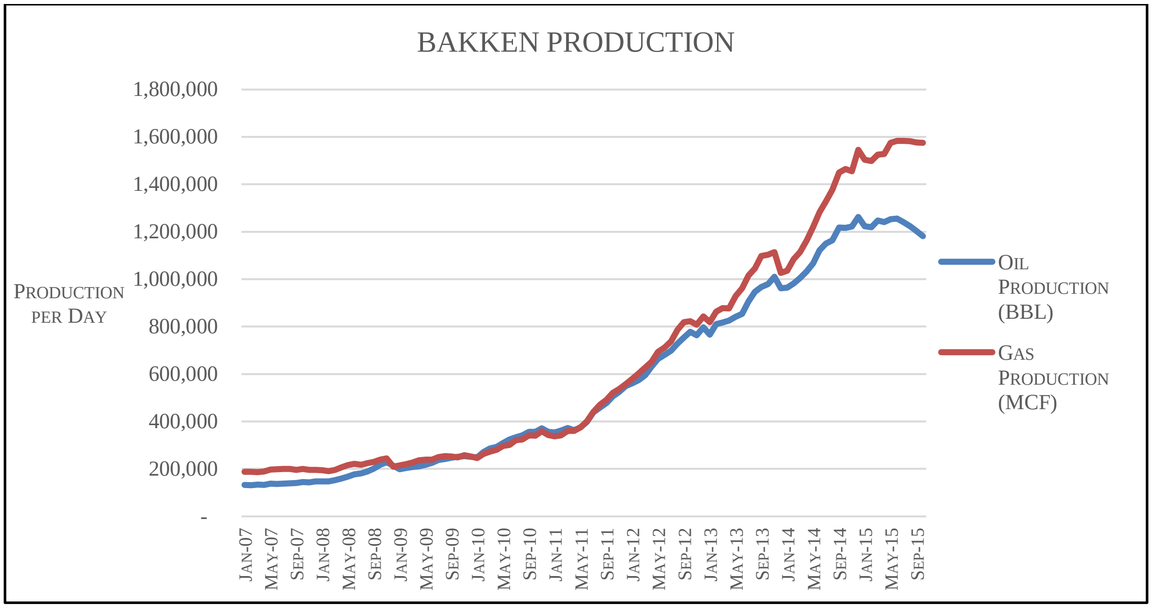

Figure 6. Bakken Formation production according to EIA monthly production report data (EIA, 2015).

Recently, oil and gas development within the prairie pothole portion of the Bakken has been very intensive (Figure 7). Corresponding with intensive production, a significant amount of infrastructure has been constructed within the region. Records obtained from the NDDMR indicate 4,496 oil and gas wells have been drilled since December 31, 2005 within the prairie pothole region in North Dakota, the majority of which taking place within four counties: Burke, Divide, Mountrail, and Williams. The number of wells permitted and drilled in those counties continues to increase (Figure 8). These trends suggest development involving surface impacts will continue along its trajectory.

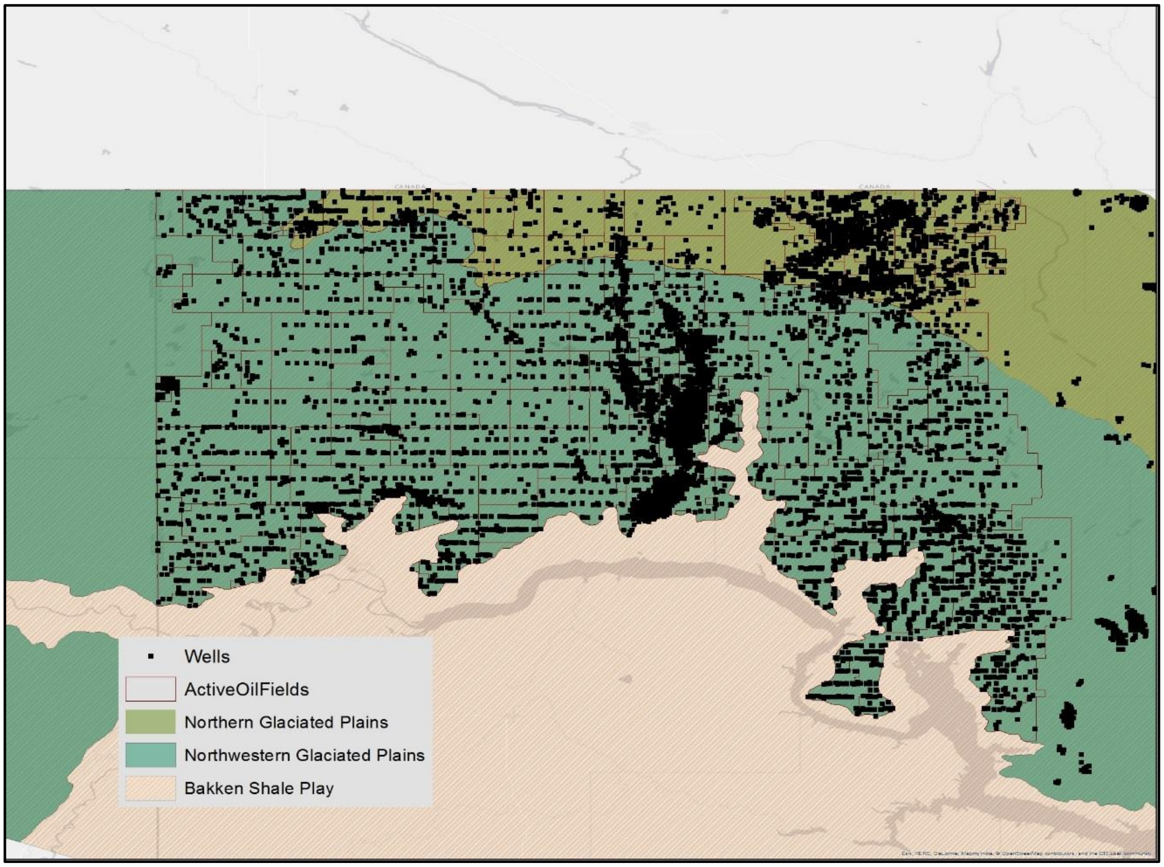

Figure 7. Oil and gas wells drilled to date within the PPR region of the Bakken formation (NDDMR, 2015).

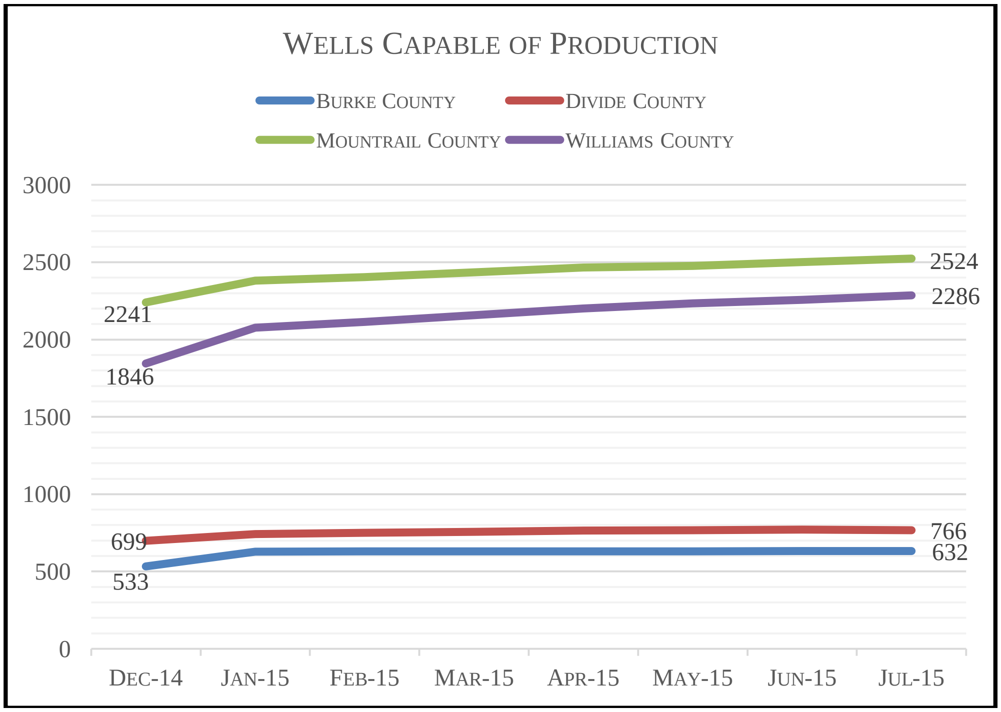

Figure 8. Monthly changes in the number of wells capable of production (NDDMR, 2015).

The Oil and Natural Gas (O&G) industry is a noted challenger to the CWR's legal status. The industry refutes the agencies' estimation of the resultant increase in jurisdiction as "grossly underestimated."[21] In its defense, an examination of JD records from the Omaha District presents the possibility of a significant change in the regulatory standards within the region.[22] The Omaha district currently does not assert jurisdiction over isolated waters unless they are located within the 100-year floodplain or connected by a tributary with a

[21] Independent Petroleum Association of America (IPAA), American Exploration & Production Council (AXPC), Western Energy Alliance (WEA), Comment to Proposed Rule, Page 3, November 14, 2014; http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OW-2011-0880-18864

[22] The Omaha District of the USACE provided a database of 264 jurisdictional determinations documented from January 2008 through October 2015 for Burke, Divide, Mountrail, and Williams Counties of North Dakota. The database was generated by the USACE's Operations and Maintenance Business Information Link Regulatory Module II (ORM II) geospatial database. The database provided useful information for determining how the regulators in the region interpret and implement the existing *Rapanos* regulations.

distinct physical connection. Figure 9 seems to suggest the Corps lacks an alternative means for assessing a significant relationship between isolated waters and TNWs[23]. The effect of the "similarly situated" provision in the CWR should bring a significant number of waters under regulation that were previously unaccounted. The result will increase indirect costs associated with the CWA Section 404 dredge and fill provisions due to a greater share of projects intersecting jurisdictional boundaries under the premise that sufficient minimization and avoidance will be difficult to achieve. A corresponding significant increase in the number of activities requiring permits can provide a crippling effect to development.

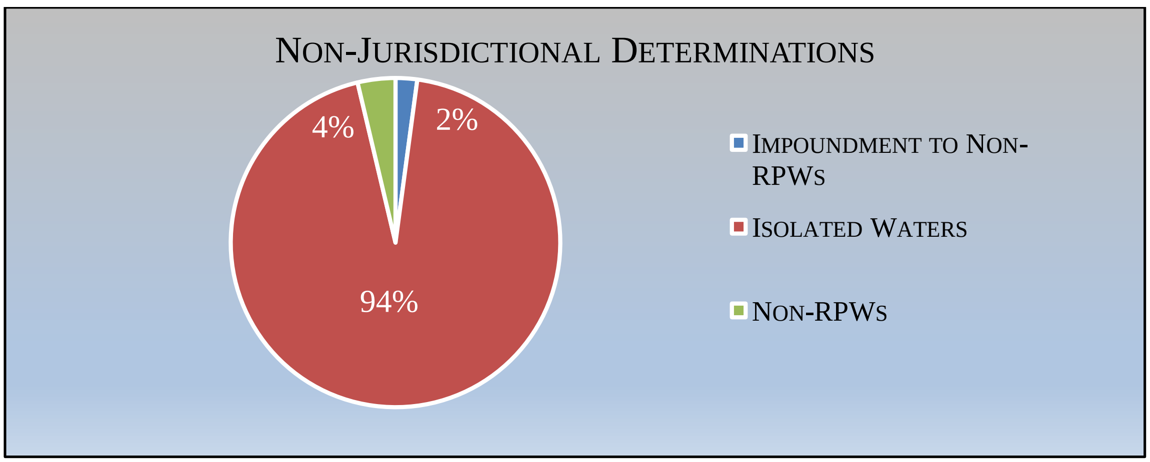

Figure 9. Corps findings of non-jurisdiction by waters type from 2008-2015 in Burke, Divide, Mountrail, and Williams Counties, North Dakota.

OBJECTIVE

The Corps has not produced any guidance pertaining to the implementation of the new provisions presented by the CWR. Few studies, if any, have attempted to evaluate both

[23] It must be noted that only 2 of the 180 jurisdictional determinations involving isolated waters were positive.

the practicality of the CWA or estimate the CWR's impact on the number of jurisdictional features at a regional level. It is uncertain whether the CWR can meet its intentions in a "similarly situated" landscape, the effects of which could prove damaging to specific industries if current development patterns prove to be no longer sustainable. The intent of this study is to investigate these issues by assessing the following:

1) What is the approximate extent of geographically isolated wetlands?
2) How can the isolated water population be described in the context of Section 404 regulations?
3) How does the CWR impact the scope of jurisdiction?
4) What is the Oil and Gas industry's approximate footprint over the last decade? Does the wetland loss rate attributed to Oil and Gas development imply significant restrictions?
5) Does the impact rate imply significant future restrictions and impacts to the waters of the region?

Chapter 2: Methods

ANALYSIS PROCEDURE

The majority of the analysis is prepared with the use of geographic information system (GIS) spatial analysis technology and incorporates known protocols for sampling, analyzing and monitoring wetland extent and trends, but on a scale narrowed to the magnitude of an oil and gas play (Johnson et al, 1999; Olsen et al, 1999; Dahl, 2011; Moulton et al, 1997; Dahl, 1999; Dahl and Stedman, 2013).

STUDY AREA

The focus of the analysis is the North Dakota portion of the Prairie Pothole Region (PPR) overlying the active oil and gas fields in the Bakken Shale (Study Region) (Figure 10).[24] The study region depicted in Figure 12 displays active oil and gas fields and their associated 12-digit hydrologic unit codes, more commonly known as watersheds.

[24] The PPR boundary is defined by data from the United States Fish and Wildlife Service (USFWS) Level III Eco-regions of the Continental United States. It includes portions of the Northwestern Glaciated Plains and the Northern Glaciated Plains eco-regions. The intersecting boundary of the Bakken Shale play was developed from data obtained from the U.S. Energy Information Agency.

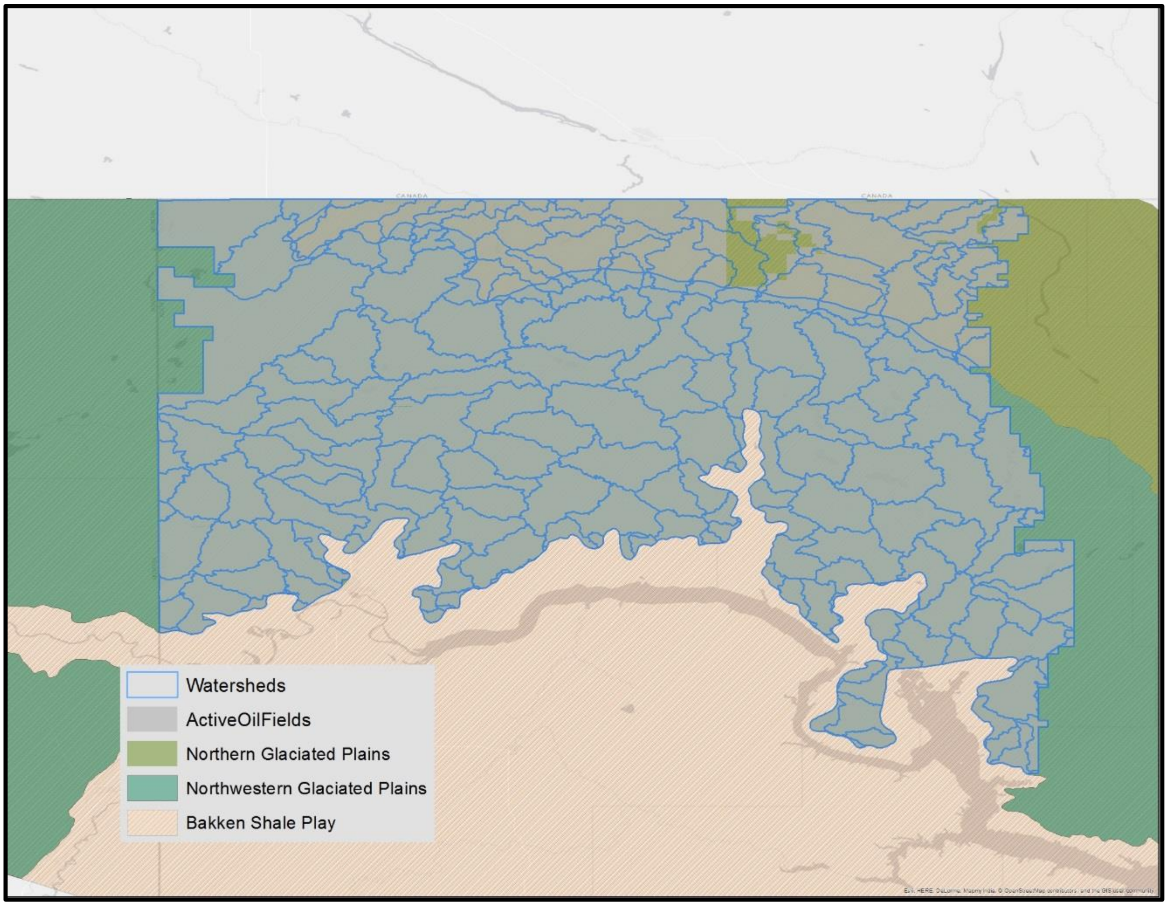

Figure 10. The intersection of the Prairie Pothole eco-regions with the active portion of the North Dakota Bakken shale (Study region).

THE EXTENT OF ISOLATED WATERS

The analysis aims to produce a quantitative measure of the extent (status) of geographically isolated wetlands, those most likely to be determined non-jurisdictional under the *Rapanos* Guidance, located within the study area. The study region was superimposed with data from the USFWS National Wetland Inventory (NWI) and the United States Geological Survey (USGS) National Hydrography Dataset (NHD). The NWI depicts current geospatially referenced information on the status, extent, characteristics, and functions of wetlands, riparian, deep-water and related aquatic habitats in priority areas.[25] The NWI dataset is specifically useful for regional and watershed scale analysis.[26] Current NWI imagery for the North Dakota study area was recorded in the 1980s according to USFWS record. The NHD represents tributary network features such as rivers, streams, canals, lakes, ponds, coastline, and dams.[27] It provides a spatial representation of the region's flow network from which particular waters may be traced downstream to TNWs, a common practice of determining jurisdiction.

A geographic definition for isolated wetlands was implemented so information could be extracted from digital data sources for tabulation and reporting purposes. Isolated wetlands were defined as wetlands with no apparent hydrological connection to traditional navigable waters. The NHD data represented a consistent base from which the analysis of wetland-stream connectivity and isolation could be conducted. The NDH represents intermittent and perennial streams within the study region. It is assumed all such streams are jurisdictional due to a physical hydrological connection to downstream TNWs.

A geospatial model was then constructed to calculate the extent of *Rapanos* wetlands in the study area. The model was intended to account for inherent limitations in NHD vector datasets such as waters located in floodplains, located adjacent to TNWs and their tributaries, and wetlands whose hydrological connection is unaccounted for (ephemeral streams). A buffer was placed around NHD lines with a total width of 300 feet. All features found within the buffer were considered jurisdictional under the *Rapanos* interpretation. The remaining isolated waters could then be extracted as the extent of geographically isolated waters in the study region.

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[25] The data set is only updated in areas that necessitate a better understanding of the development and conservation trends of wetlands. Therefore, the images may be outdated for rural areas such as the study region in this report. However, because this study aims to assess recent impacts, the historical data is of use.

[26] It is important to note the dataset does not attempt to define limits of jurisdiction.

[27] The NHD does not include ephemeral waterways which, if demonstrating certain physical characteristics of flow, would qualify as a jurisdictional feature.

CWR Impact On Jurisdiction

The previous section was designed to produce an estimate of non-jurisdictional wetlands according to the *Rapanos* guidance. The CWR provisions were then applied to the resulting set of waters to produce various estimates of increased jurisdiction under different scenarios (Table 1).

Scenario	Description
Current Jurisdiction	*Rapanos* Waters
Worst Case	*Rapanos* + All Isolated Waters
Density	*Rapanos* + Similarly Situated Waters (SSW)
Within 4000 Ft. of an OHWM	*Rapanos* + SSW + 100% of Case-Specific Waters (CSW)
	Rapanos + SSW + 75% of CSW
	Rapanos + SSW + 50% of CSW
	Rapanos + SSW + 25% of CSW

Table 1. Scenarios used to estimate various estimates of the increase in jurisdictional features.

The "Current Jurisdiction" scenario utilizes the geospatial model described in the previous section. The waters captured by the model are referred to as *Rapanos* waters and represent the waters currently being regulated in the region before the implementation of the CWR. The "Worst Case" scenario assumes the CWR assert jurisdiction over all isolated waters within the PPR according to the most lenient interpretation of the "Similarly Situated" provision.

In order to put the similarly situated provision into practice, the "Density" scenario utilizes a quantifiable means to determine which waters are "similarly situated." To do so, the study region was overlain with a grid of approximately 5,154 mi^2 sampling plots. Density was then calculated by measuring the number of individual waters per mi^2. The threshold for determining a similarly situated designation was chosen as the average density per mi^2 of all sample plots.

As previously noted, the CWR offers another provision to analyze waters that are not determined to be similarly situated. Waters found to be within 4,000 ft. of an ordinary high water mark (OHWM) are subject to a case-specific analysis of a significant nexus. To assess the impacts of this provision, a 4000 ft. buffer was placed around all stream and open water data. Waters captured within this buffer were then quantified and included in possible estimates of jurisdiction. This study assumes only a certain percentage of these waters would be found to have a significant nexus and become jurisdictional accordingly.

IMPACT TREND

A substantial increase in the number of jurisdictional features should result in a considerable increase in the number of regulated impacts. A sampling procedure was designed to measure the impacts to isolated waters from O&G E&P activity during the relatively intense development period from 2006-2014. The DMR oil well database was filtered for all wells drilled after December 31, 2005. A total of 4,496 wells were sampled from the study area, the distribution of which is displayed in Figure 11.

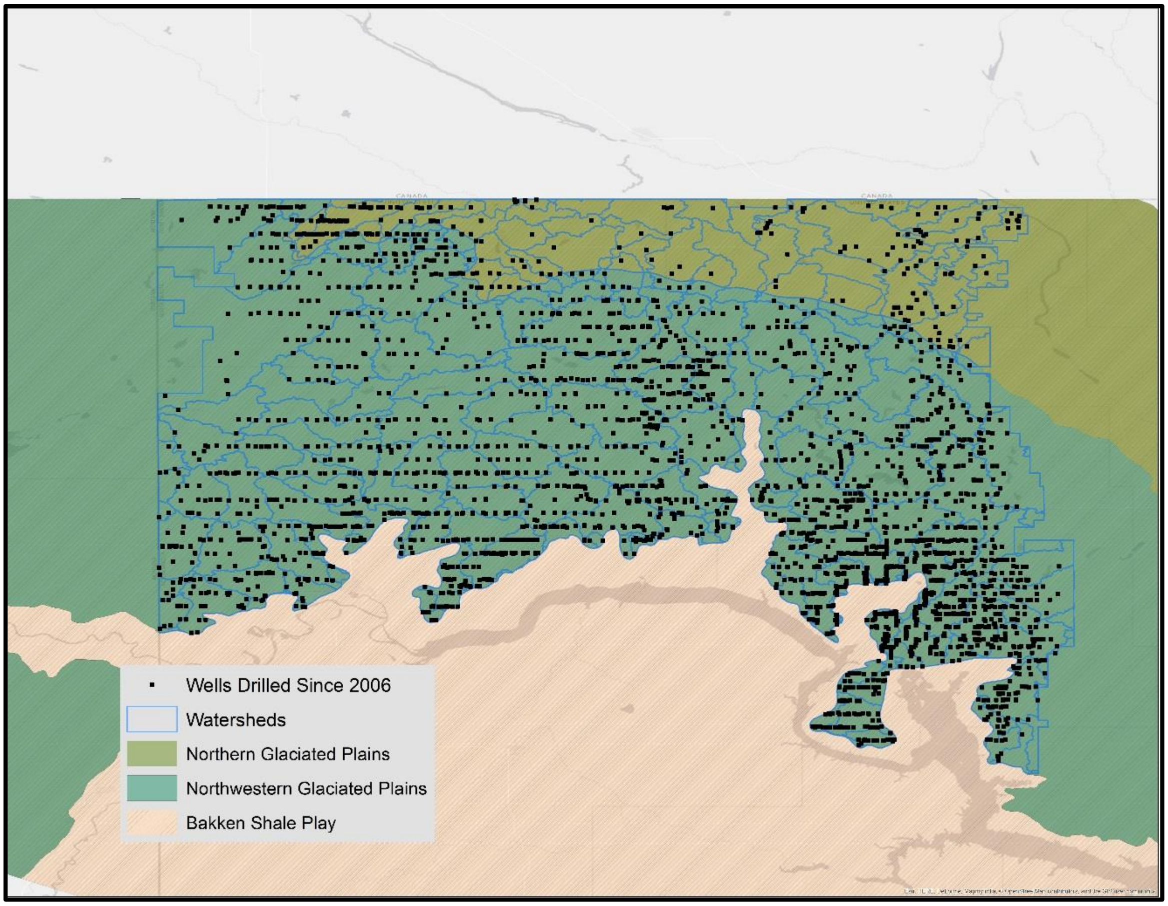

Figure 11. Spatial extent of the wells drilled from 2006-2014.

The observable characteristics present in remotely sensed digital imagery were depended upon to provide a quantifiable estimate of isolated feature area gains and losses (trend) due to surface impacts over the time period from January 2006 to the latest available imagery for the study area (2014). The image interpretation procedures in this report are documented in a study by Dahl and Bergeson (2009). United States Dept. of Agriculture (USDA) Farm Service Agency National Agriculture Imagery Program (NAIP) aerial imagery were downloaded for the relevant counties for each year in the study period. Changes to the spatial extent of isolated waters as a result of well pad and access road development were recorded. Impacts in the study area usually involved the identification of vegetation removal and fill without further development beyond the construction of various O&G facilities. Only obvious cases of fill as a result of O&G activity were classified as impacts. Figure 12 provides an example of an impact altering the spatial extent of an isolated water assumed jurisdictional during the study period.

Figure 12. Impact example occurring from the development of a well pad observed using NAIP imagery from 2010 and 2013.

STUDY LIMITATIONS

This study did not benefit from quality control measures including the ability to perform ground verification of identified features to resolve issues specific to outdated data, image interpretation and aerial extent. In addition, it is possible the image resolution and quality of the 1980s prevented the interpretation of all wetlands in the PPR ecosystem. There is no access to the original photography used by the North Dakota NWI project for verification. It is assumed the NWI mapping procedure did not misinterpret any upland areas as WOUS. A study by Jacob et al (2014) produced few false positives in the NWI dataset claiming the NWI maps “identify precisely the wetlands that were observable using the photography available at the time.” It is possible, however, the NWI survey was not able to identify all wetlands present at the time. As a result, the extent calculations in this study may represent an estimation of the minimum. Lastly, this report only estimates the trend in wetland extent and impacts from a regulatory perspective; it does not draw conclusions regarding the quality and condition of the PPR ecosystem.

Chapter 3: Results

ISOLATED WATER EXTENT

There are approximately 170,000 acres of wetlands located within the estimated 5.4 million acre study area. Results indicate the amount of currently protected waters consists of only a small fraction of the region's total aquatic resources.

Rapanos waters make up 22 percent of the wetland acreage at an average of 2 acres per wetland and 12% of the total number of wetlands. Isolated waters constitute 78 percent of the study area's wetland acreage while averaging 1 acre per wetland and 88 percent of the total number of wetlands. These results match the estimate produced by Dahl et al. (2014) where 88 percent of all wetland basins in the entire PPR were geospatially isolated. Results were lower than expected when considering Dahl et al (2014) estimated wetland density to be the highest in North Dakota. Table 2 presents the extent of different regulatory categories of waters. Figure 13 displays the geospatial extent of waters as defined by the geospatial model's determination of isolation.

	Acres	Number	Percentage of Total (Acres)	Percentage of Total (Number)	Mean Acreage
Study Region	5,419,628	217	--	--	24,975
All Waters	168,705	148,500	100%	100%	1.14
***Rapanos* Waters**	37,046	18,397	22%	12%	2.01
Isolated Waters	131,659	130,103	78%	88%	1.01

Table 2. The extent of prairie potholes in the study region by category.

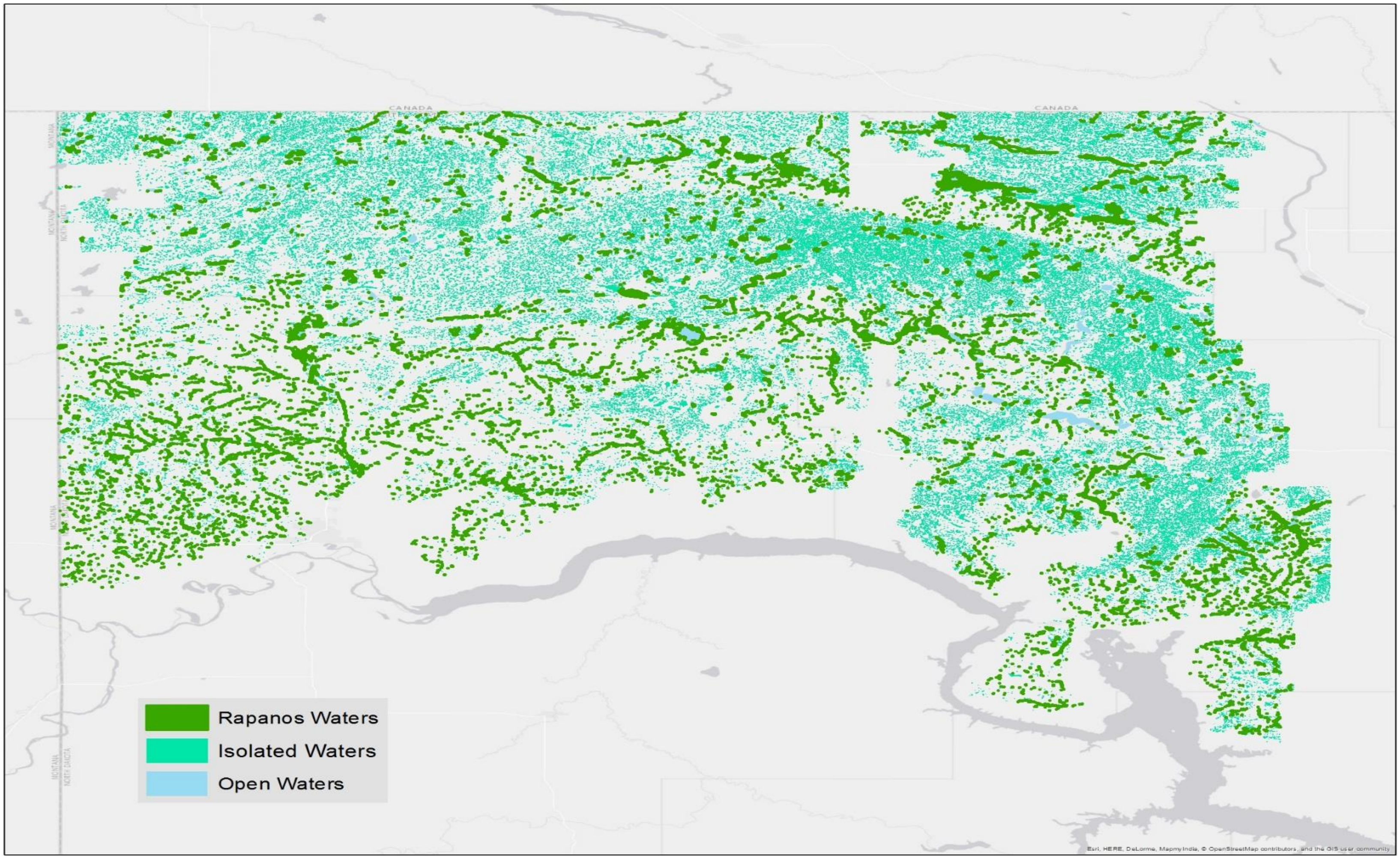

Figure 13. Analysis results displaying the geospatial extent of isolated waters according to *Rapanos*.

On average, isolated waters make up 77 percent of the total number of wetlands and 70 percent of the total acreage of wetlands within each sampled 12-digit HUC. The highest occurrence of isolated wetlands with respect to number and area were found within the Robinson Lake watershed (Map Id Number 41, Appendix A) with a total of 8,334 isolated waters making up 9,696 acres. Isolated water extent results for each HUC in the study area can be found in Appendix A. Figure 14 presents a spatial representation of isolated water area and number with respect to the total number of waters in each HUC highlighting not only the watersheds with the most isolated waters but also the distribution of jurisdictional streams and open waters in the study region.

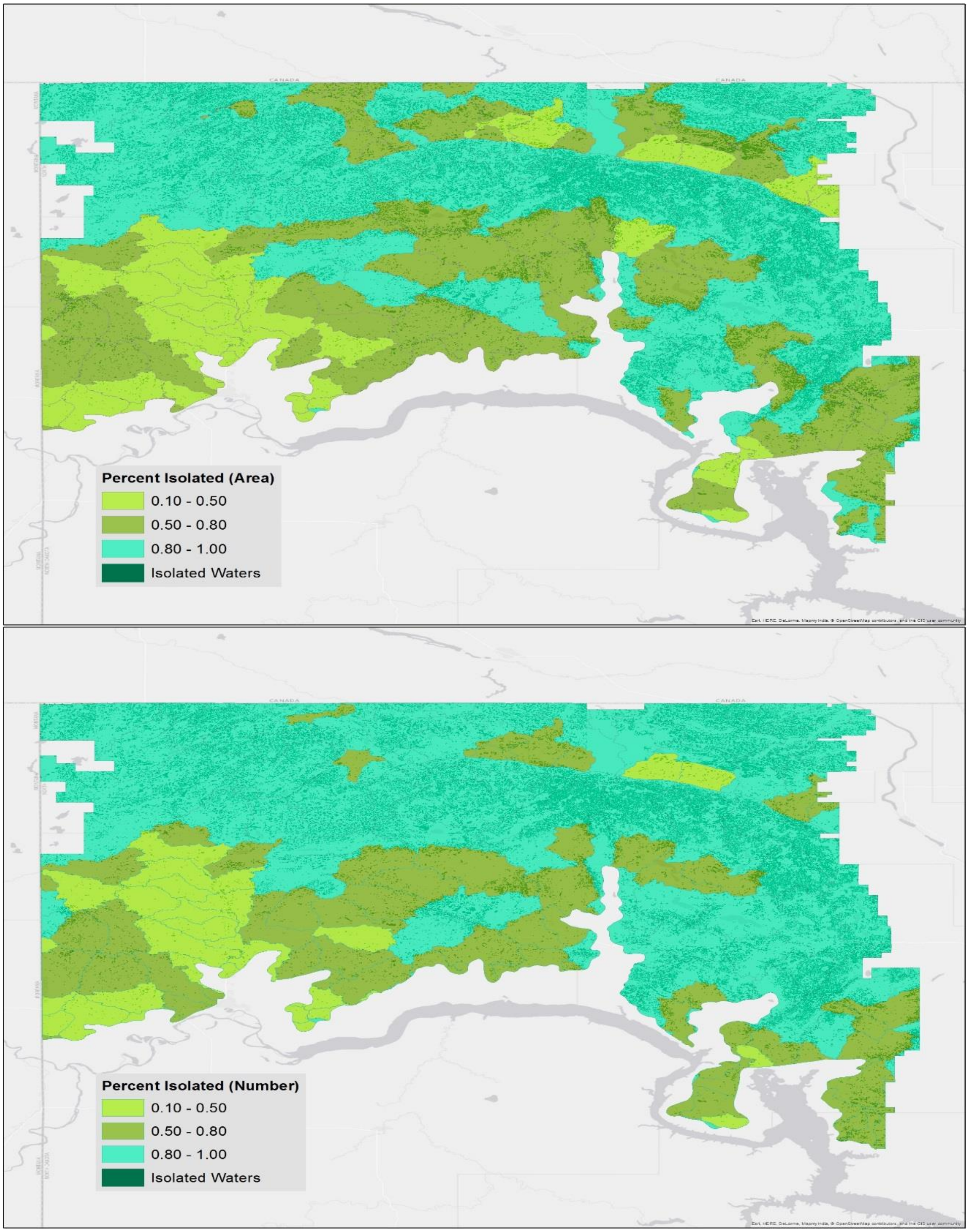

Figure 14. The percentage of isolation among the total waters population by area (top) and number (bottom) according to each HUC.

JURISDICTIONAL IMPACT

After highlighting the extent, location, and occurrence of isolated waters in the study region, an attempt was made to interpret how the CWR would assert jurisdiction over waters previously found to be non-jurisdictional under *Rapanos*. Beyond the institution of a couple bright line boundaries, the CWR does not provide a singular prescriptive measure for identifying jurisdictional isolated waters that fall outside these boundaries but within designated "similarly situated" regions. Instead, the CWR may accept any analysis that suggests the contribution of a number of important ecological functions.

Seven scenarios were tested to determine the expected impact on the number of jurisdictional features. Under the worst case scenario, the agencies would assume all isolated waters in the study region are similarly situated resulting in an increase in jurisdiction of 88 percent of the total number of waters and 78 percent of the total area.

The number of isolated waters per mi^2 was sampled to provide a quantifiable estimate of similarly situated waters. On average, each square mile in the study region contained 24 isolated waters. The isolated waters located within a sample cell meeting this threshold density value were determined to be jurisdictional along with *Rapanos* waters. The result is a 65% increase in jurisdiction raising the total number of jurisdictional waters to 77% of all waters in the study region. The total acreage increases by 45% to 67% of all waters.

The case-specific provision, which implements a 4000 ft. buffer to all OHWMs, was then applied to isolated waters located in the region, but not captured by the density threshold. If 100 percent of those waters are determined to be jurisdictional, the number of jurisdictional features, in addition to *Rapanos* waters and similarly situated waters, increases by 14 percent to 91% of all waters. The acreage increases by 12 percent 79 percent of all waters. To address the almost certain fact that some, if not all, of these waters will be determined non-jurisdictional, the total percentage was reduced in quartile increments to 25 percent. For every 25 percent decrease in the number of case-specific waters found jurisdictional, the corresponding decrease in jurisdiction is about 3 percent for both total wetland numbers and wetland acreage. If 25 percent of all case-specific waters are determined jurisdictional, the number and area of waters increases by 4 and 3 percent to 81 and 70 percent respectively. Tables 3 and 4 display the impact each scenario has on the number and area of jurisdiction respectively. Figure 15 displays the distribution similarly situated waters based on the estimation of density. Figure 16 displays the spatial extent of waters based upon the potential jurisdictional scenario.

Scenario	Description	# of Waters	% Increase in Jurisdiction	Total % of Jurisdictional Waters
Current Jurisdiction	*Rapanos* Waters	18,397	12%	N/A
Worst Case	All Isolated Waters	130,103	88%	100%
Density	SSW	96,360	65%	77%
Within 4000 ft. of an OHWM	100% of CSW	21,244	14%	91%
	75% of CSW	15,933	11%	88%
	50% of CSW	10,622	7%	84%
	25% of CSW	5,311	4%	81%

Table 3. Percent increase in the number of jurisdictional features by scenario.

Scenario	Description	Acres of Waters	% Increase in Jurisdiction	Total % of Jurisdictional Acreage
Current Jurisdiction	*Rapanos* Waters	37,046	22%	N/A
Worst Case	All Isolated Waters	131,659	78%	100%
Density	SSW	76,727	45%	67%
Within 4000 ft. of an OHWM	100% of CSW	19,514	12%	79%
	75% of CSW	14,635	9%	76%
	50% of CSW	9,757	6%	73%
	25% of CSW	4,878	3%	70%

Table 4. Percent increase in the area (acres) of jurisdictional features by scenario.

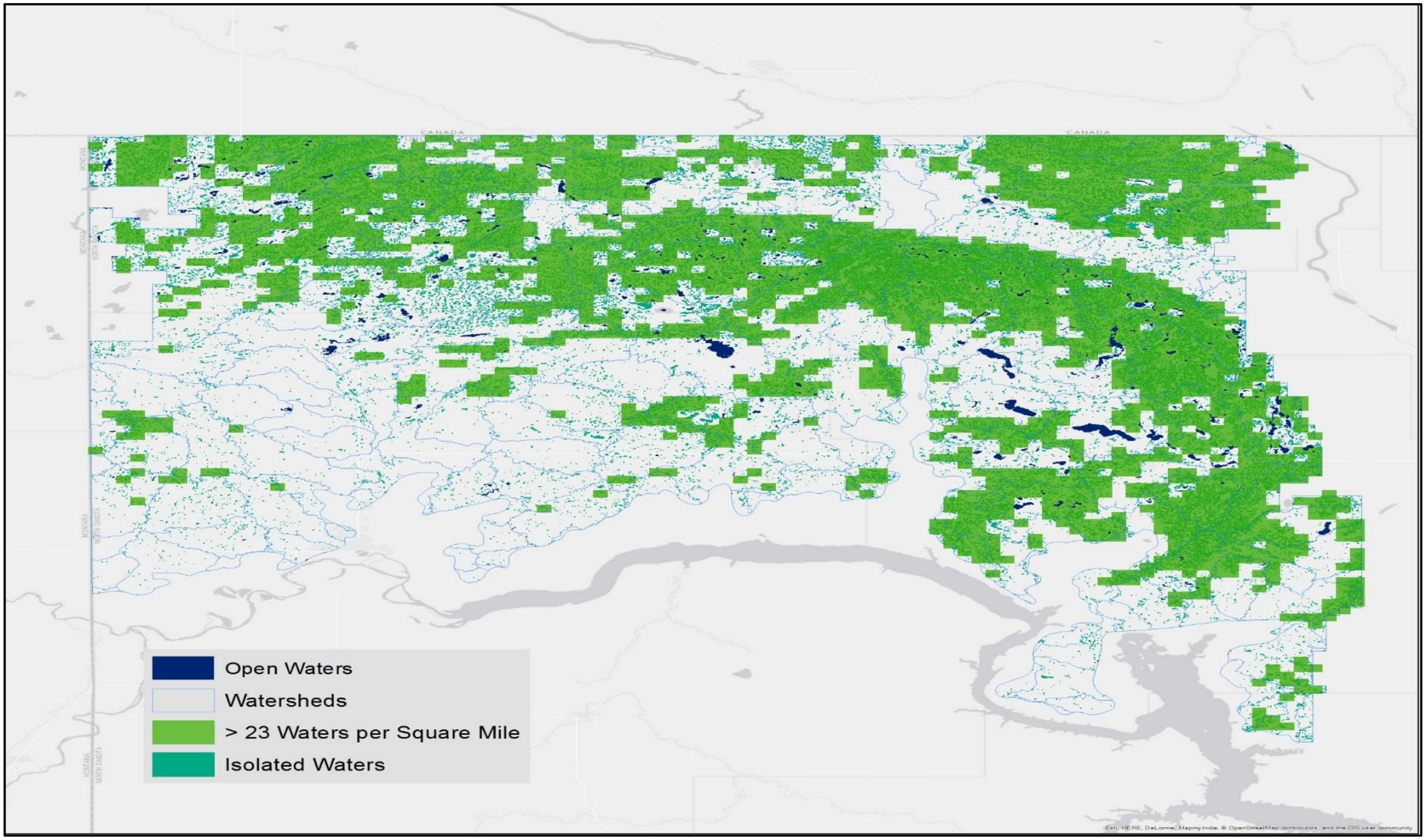

Figure 15. Distribution of similarly situated waters based on density of waters per square mile.

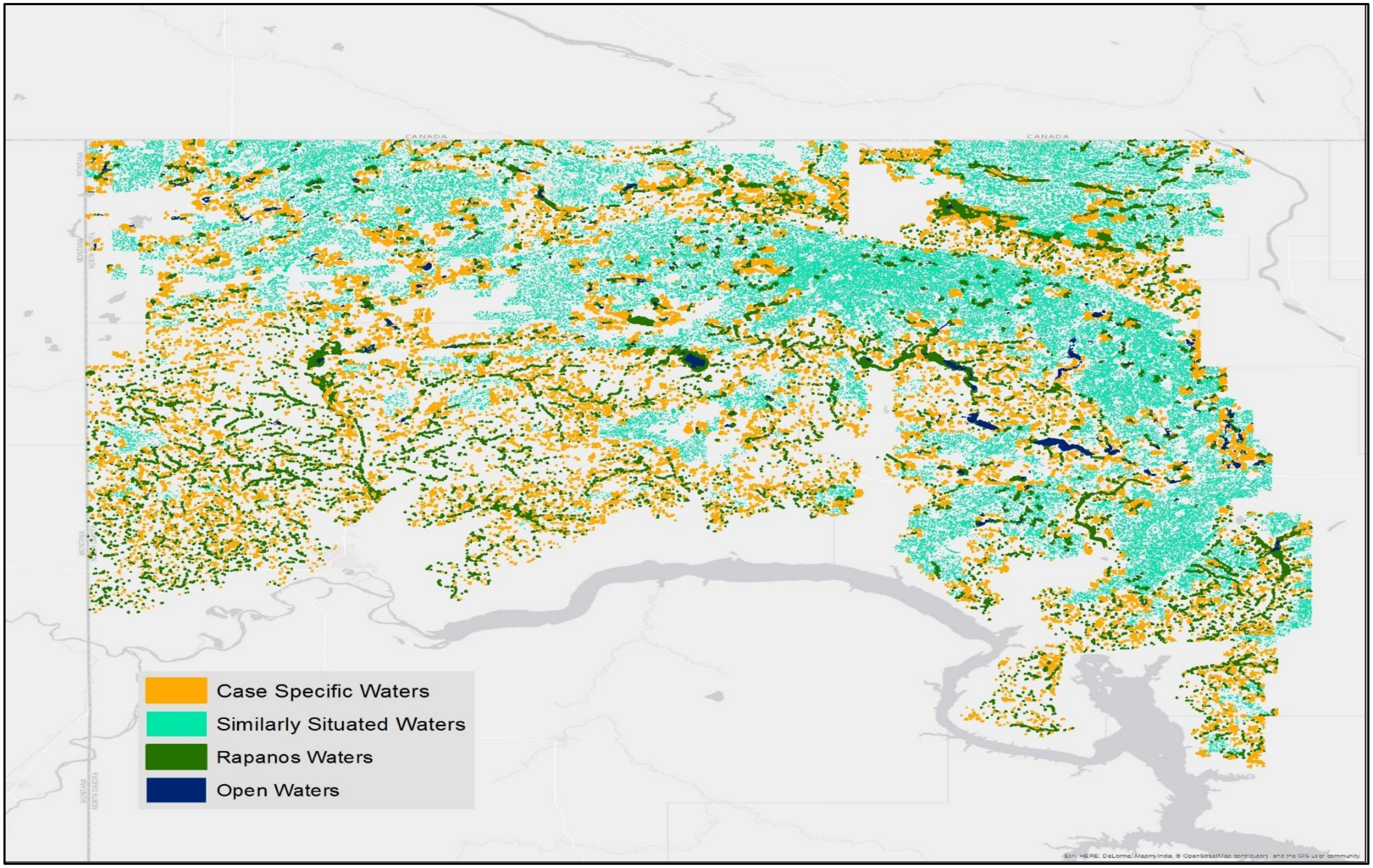

Figure 16. Spatial extent of isolated waters captured by different jurisdictional scenarios.

Impact Trend

The distribution of isolated water surface area is significant to O&G operations due to the correlation between the regulatory burden and the size of impact. The Corps is notified when impacts reach a threshold of a tenth of an acre, with compensatory mitigation often required in addition to a permit.[28] According to the cumulative frequency distribution of isolated waters by area (Figure 17), 66 percent of the isolated waters occupy an area less than the IP specific threshold of .5 acre (Figure 18). However, 84 percent of the waters, would require both permitting and mitigation if impacted in entirety.

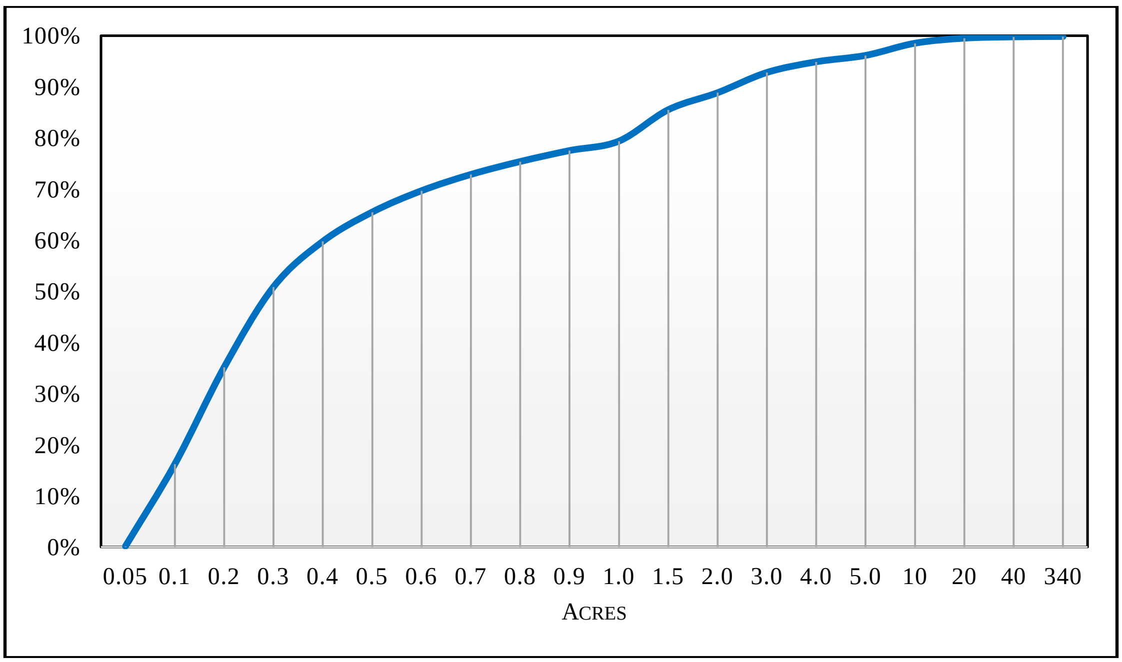

Figure 17. The cumulative frequency distribution of isolated waters by surface area (acres).

[28] Impacts above 0.1 acre and below 0.5 acre are permitted under a Nationwide Permit (NWP). Impacts over .5 acre require authorization under an Individual Permit (IP).

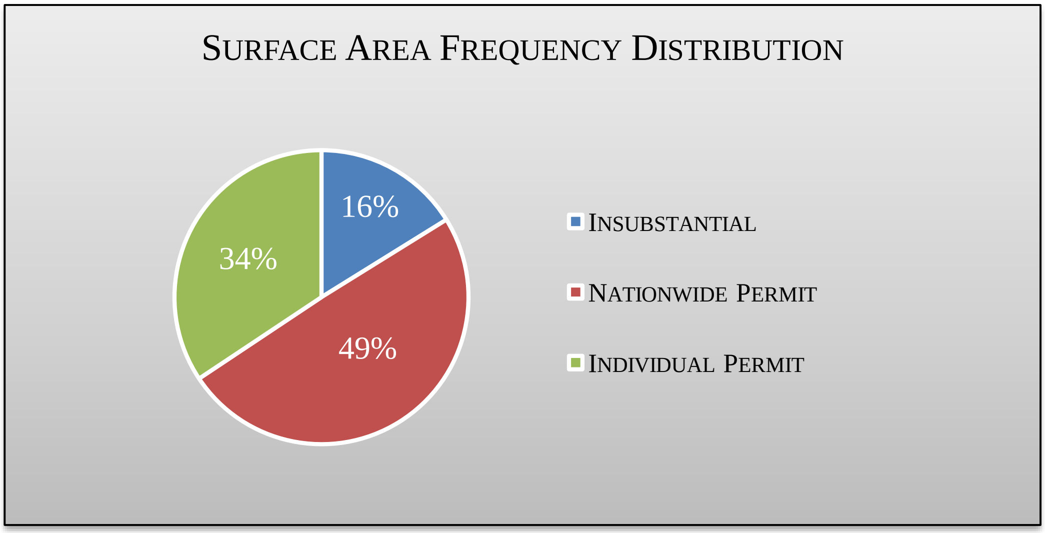

Figure 18. The proportion of isolated water acreage according to regulatory impact thresholds.

The density of isolated waters in a particular landscape is also of concern. Areas of high density provide less room for the siting of infrastructure. HUCs (watersheds) vary by the total surface of wetlands they contain, which may or may not be a reflection of the number of waters. The ratio describing the acres of isolated waters per acre of watershed can provide a very broad level estimate of the amount of impacts. Figure 19 displays the cumulative frequency distribution of the expected impacts per HUC from the development of a hypothetical well pad 5 acres. Figure 20 displays the HUCs in proportion to the expected regulatory action associated with the impacts.[29]

[29] A variety of infrastructure is developed alongside wells pads during O&G exploration and production activities including access roads, storage facilities and gathering lines. A five-acre well pad is only a proportion of the expected impacts for a single and complete project.

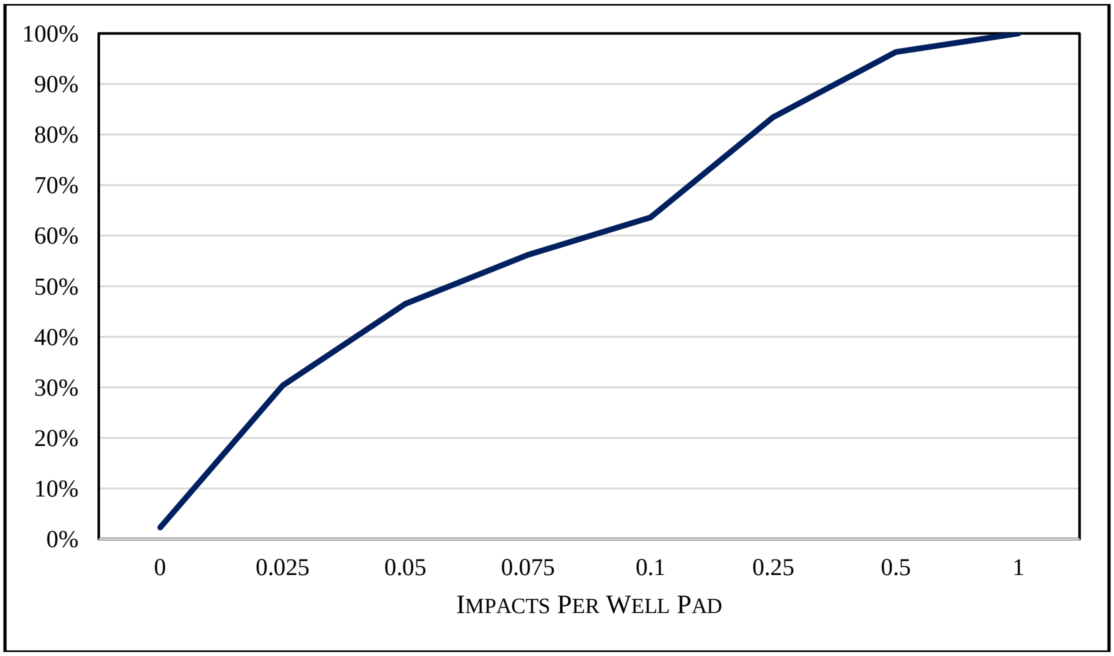

Figure 19. Cumulative frequency distribution of HUCs by of the expected impacts from a hypothetical well pad.

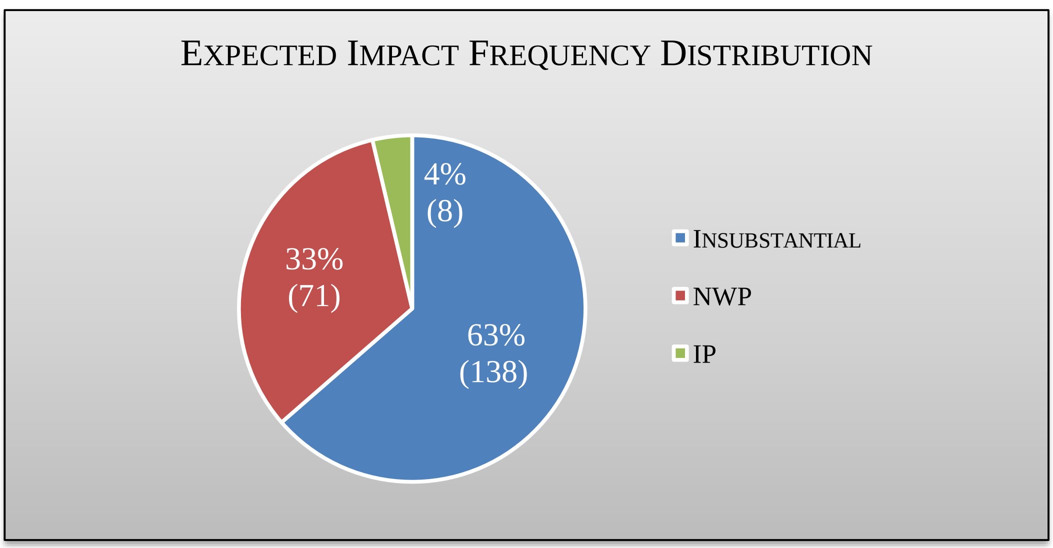

Figure 20. The proportion of impact triggers for a single well pad in each HUC.

Both broad-level statistical measures show a potential cause for concern for those operating in the region. However, the impact trend analysis produced less predictive results. From 2006 to 2015, analysis methods documented 216 separate impacts to 113 acres of isolated waters from the development of 4,728 wells and their associated access roads, an impact rate of just under 5 percent.[30] Table 5 displays the impacts results tabulated by year.

Year of Impact	# of Impacts	Acres of Impacts
2006	8	6.95
2007	2	1.99
2008	19	17.88
2009	23	4.22
2010	47	31.51
2011	39	10.37
2012	36	16.71
2013	24	13.58
2014	17	9.09
2015 [31]	1	0.40
Total	216	112.7

Table 5. Summary of impacts to isolated waters during the study period

The majority (71%) of impacts would trigger a NWP due to the amount of acres impacted, while twenty-two percent would require an IP. The remaining impacts would be insubstantial according to regulatory guidelines (Figure 21). Overall, an average of

[30] The impact incident rate represents a low value. A certain percentage of well-pads contain multiple wells. Only one impact was documented for each well pad in this scenario, not each well.
[31] Partial data available due to time of analysis.

approximately 24 impacts is a surprisingly small number given the unregulated status and perceived quantity of isolated waters, the developmental intensity in the region, and the assumed lack of environmental concern by the industry under analysis. Figure 22 displays the spatial distribution of impacts by 12-digit HUC.

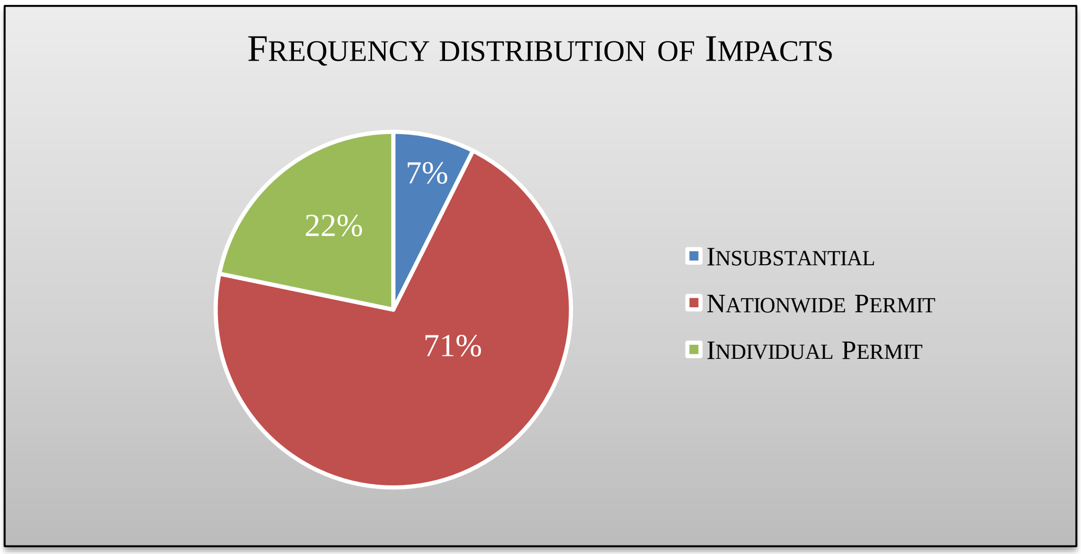

Figure 21. The surface area (acres) distribution of impacts according to different regulatory impact thresholds.

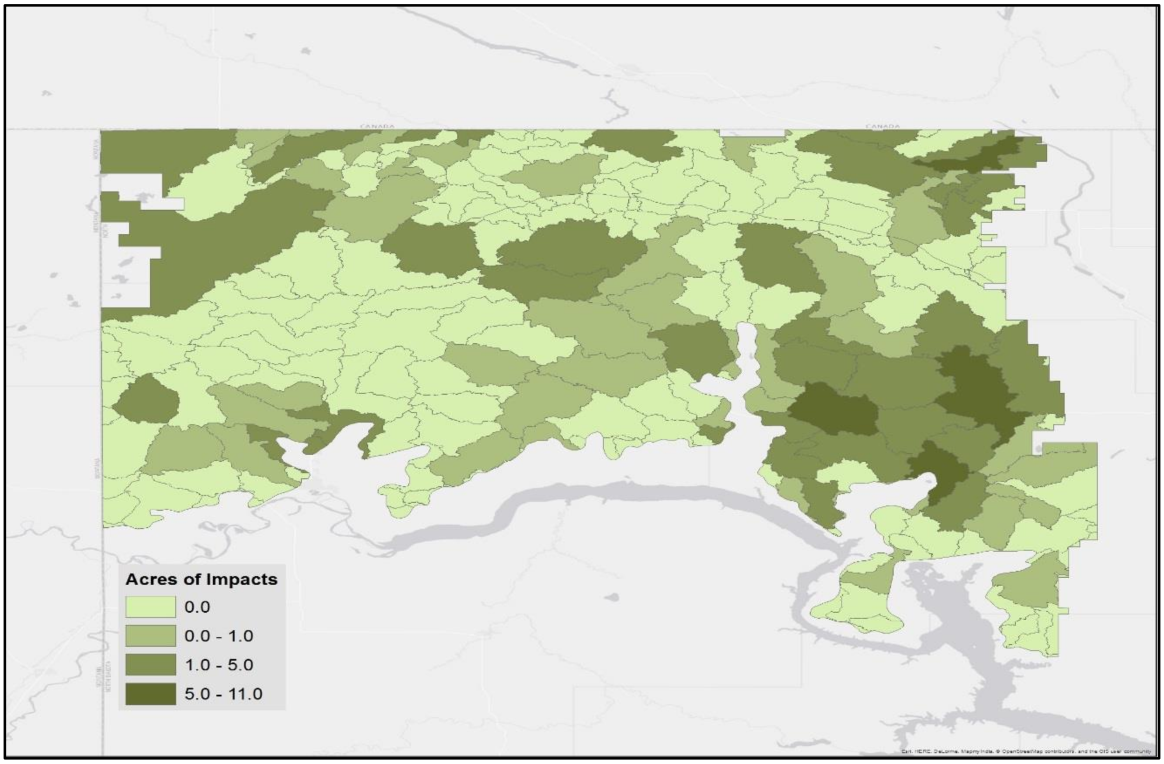

Figure 22. Distribution of impacts per 12 digit HUC.

Chapter 4: Implications

Long Term Development Trend

The relationship between the number of wells and the number of impacts during the study period was examined in an attempt predict the long-term implications a sustained rate of O&G development may have on the region. The data suggests there could be a positive correlation between the number of wells drilled per year and the amount of impacts (Figure 23). However, there is a sharp decline in impacts beginning in 2010 as the number of wells per year continues to increase. This may be attributed to other less quantifiable influences such as operator-specific behavior or economic conditions. In addition, the Proposed CWR was not published until 2014.

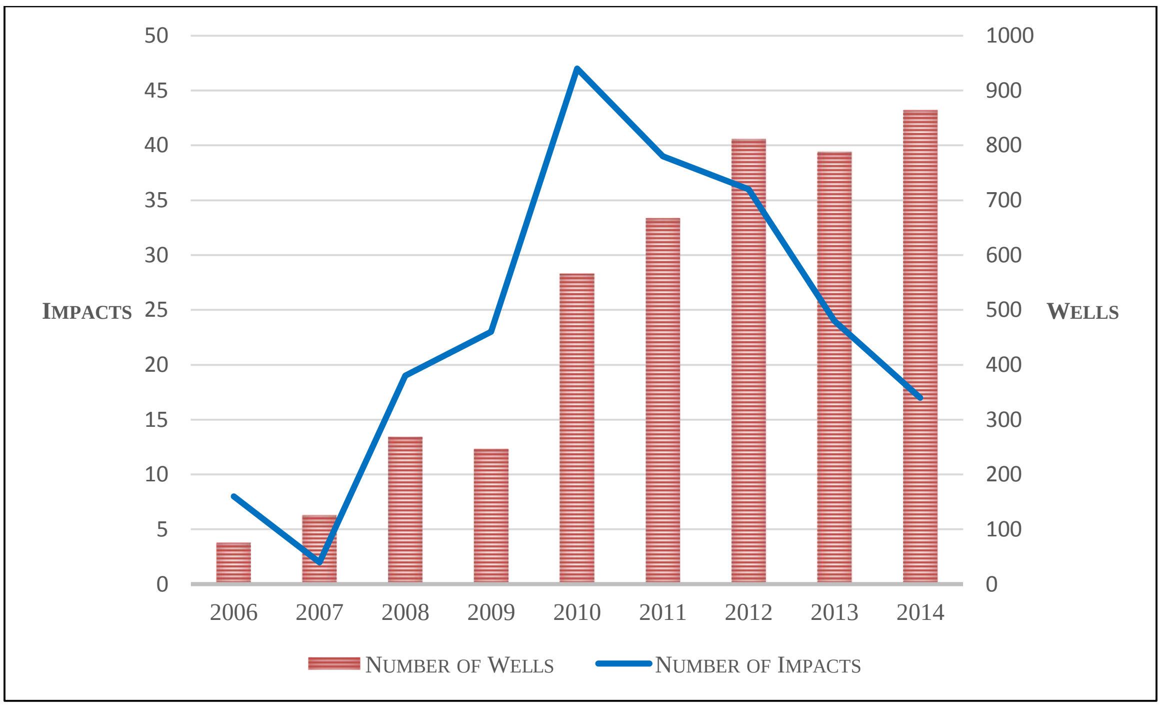

Figure 23. The number of impacts per year in relation to the total number of wells drilled per year.

When the number of wells is adjusted to the number of wells drilled per year in high density areas, the data appears to display a stronger correlation to the amount of impacts per year (Figure 24).

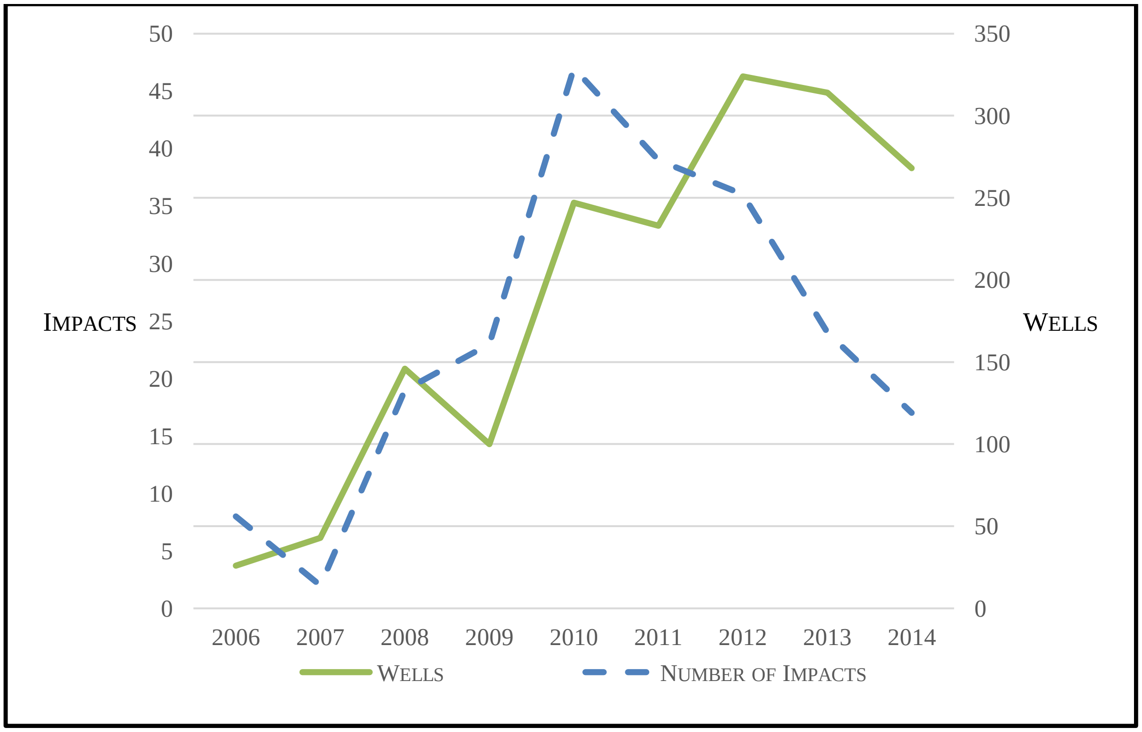

Figure 24. Number of impacts per year in relation to the corresponding number of wells drilled in high density cells (mi^2).

A linear regression analysis was performed to determine the precise relationship between impacts and the number of wells drilled in high density locations per year (Figure 25). More specifically, whether or not an increase in the amount of wells in those locations corresponds to an increase in impacts. Results provided insight into the practicality of the relationship, indicating 48 percent of the impacts may be explained by the location of wells.

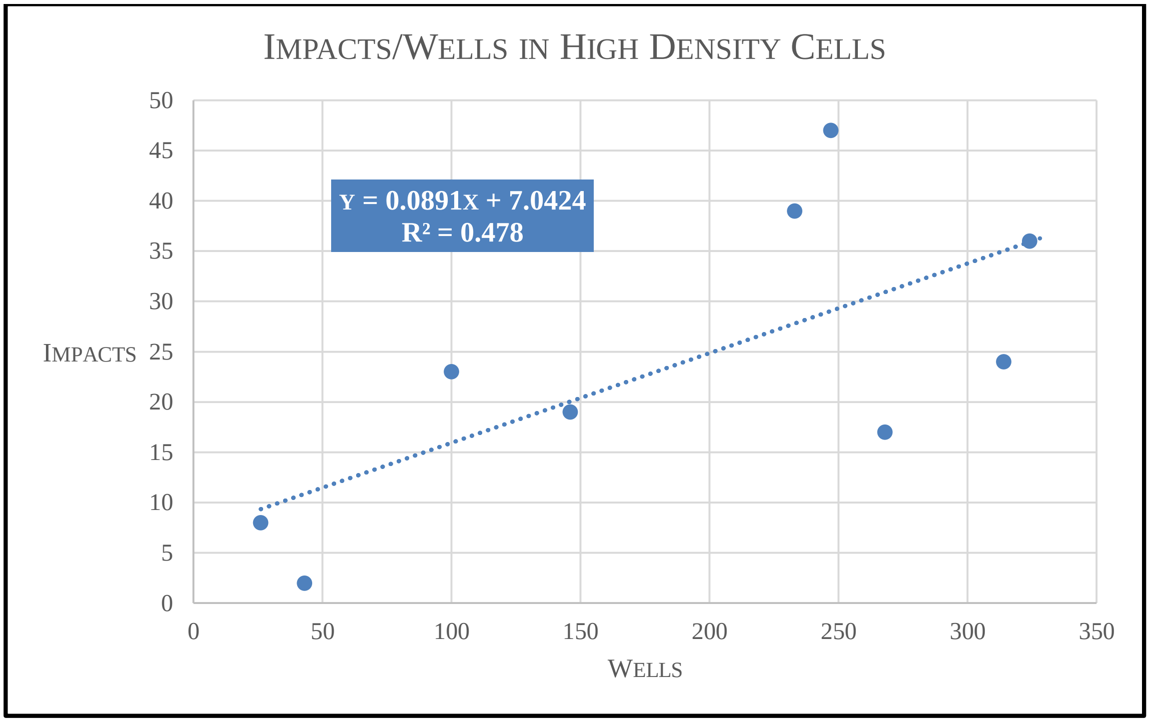

Figure 25. Linear regression model for number of impacts as a function of the number of wells in high density locations.

Assuming O&G development continues along its trend, the number of wells drilled in high density areas was forecasted out over a 10 year period (Figure 26). This was accomplished using the trend associated with a three-year moving average of the raw well number data.[32] Plugging in the forecasted number of wells produced the number of impacts per year displayed in Figure 27 and summarized in Table 6. Analysis results demonstrate the potential for 250-700 impacts at the current rate of development.

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[32] The projected number of wells was within reason when assuming 12 wells could be drilled within each mi^2 high density cell. Subtracting the existing number of wells form the estimated total produced the possibility of an additional 22,150 wells. Forecasted totals lie well below that figure.

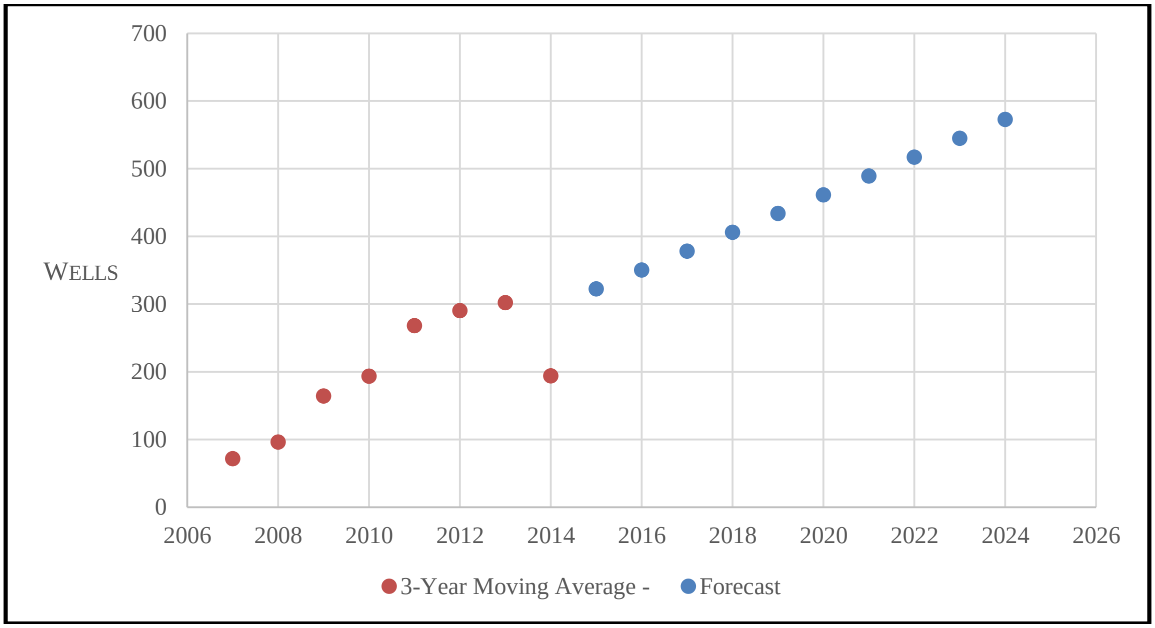

Figure 26. Estimated number of wells drilled in high density locations from 2015-2024.

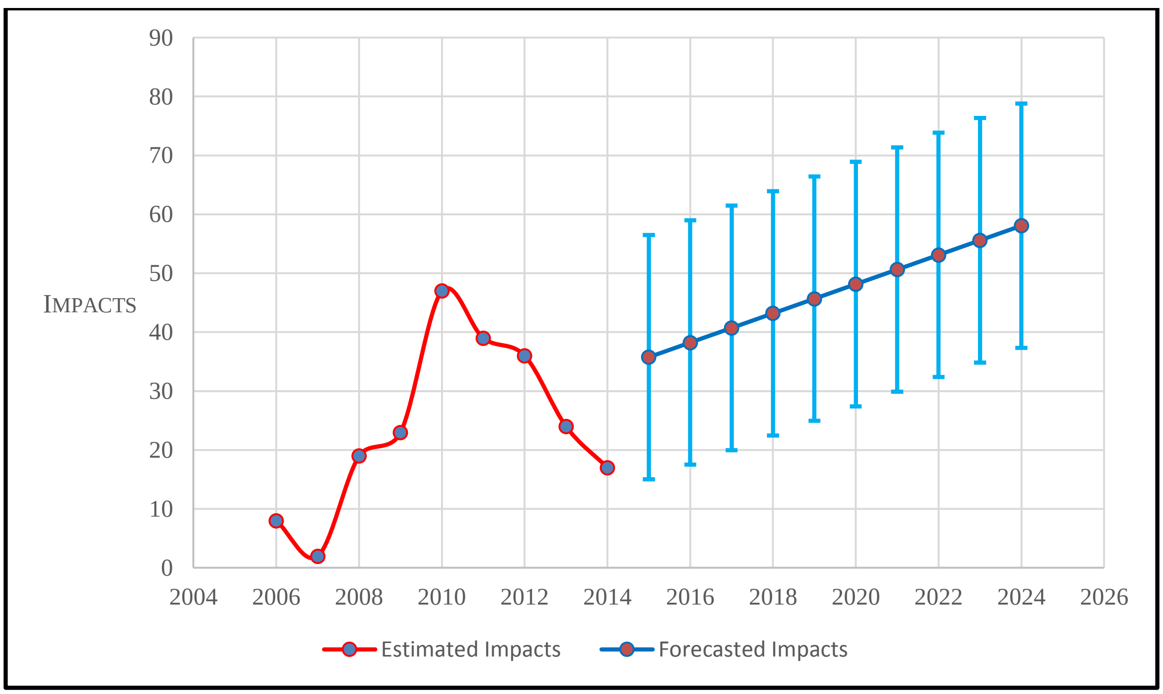

Figure 27. Estimated number of impacts according to the number of wells in high density locations from 2015-2024.

Year	Wells in High Density	Predicted Impacts	± 95% Confidence Interval (~21)	
2015	322	36	57	15
2016	350	38	59	18
2017	378	41	61	20
2018	406	43	64	22
2019	434	46	66	25
2020	462	48	69	27
2021	489	51	71	30
2022	517	53	74	32
2023	545	56	76	35
2024	573	58	79	37
Total	4476	469	677	262

Table 6. Summarized results of the forecasted impacts from 2015-2024.

Forecasted impacts were tabulated according to the isolated water regulatory impact threshold frequency distribution (Figure 18, Page 54) for further regulatory and economic analysis. Results indicate the number of IPs generated from the forecasted development could range from 89 – 230 permits while the number of NWP triggers could range from 128 to 332. The number of insubstantial impacts touches a minimum of 42 and a maximum of 108 (Table 7).

Year	Max IP	Min IP	Max NWP	Min NWP	Max Insubstantial	Min Insubstantial
2015	19	5	28	7	9	2
2016	20	6	2	9	9	3
2017	21	7	30	10	10	3
2018	22	8	31	11	10	4
2019	23	8	33	12	11	4
2020	23	9	34	13	11	4
2021	24	10	35	15	11	5
2022	25	11	36	16	12	5
2023	26	12	37	17	12	6
2024	27	13	39	18	13	6
Total	230	89	332	128	108	42

Table 7. Estimated number of future permits according to the impact forecast.

Economic Impacts

The expansion of CWA jurisdiction is anticipated to levy indirect costs associated with the CWA's Section 404 permitting program. Quantifiable costs fall into two categories: permit application costs and compensatory mitigation costs. Permit application costs rely upon estimates of the number of permit applications, the impacts per permit, and a unit permit application cost.

The unit application was borrowed from Sunding and Zilberman (2002). Their study produced a correlation between the amount of permitted impacts and the cost of preparing an IP or NWP. The estimates include a fixed cost component plus an additional cost component dependent on the amount of acres impacted (Table 8).

Compensatory mitigation unit costs are very difficult to estimate. Costs vary regionally based on the impacted watershed, land acquisition, supply and demand for credit units, the type of mitigation mechanism performed and a variety of natural factors that could impede the development of the compensation instrument. The EPA estimated unit mitigation cost ranges from $41,572 to $111,985 per acre of wetlands mitigated (USEPA, 2015). Total compensatory mitigation costs are calculated by multiplying the number of units of mitigation (acres) by the unit cost ($/acre).

	Fixed Cost	Variable Cost ($/Acre)
Compensatory Mitigation Cost (USEPA, 2015)	N/A	$41,572 – $111,985
IP Application Cost (Sunding & Zilberman, 2002) (2014$)	$62,000/Permit	$16,800
NWP Application Cost (Sunding & Zilberman, 2002) (2014$)	$23,900/Permit	$13,200

Table 8. Unit costs for permit application finalization and compensatory mitigation.

If all of the isolated waters impacted by current wells in this study were considered jurisdictional, the total economic impact from the inclusion of isolated waters would result in $12.1 to $19.7 million in indirect costs during the study period (Table 9), or an industry-wide annual cost of $1.4 to $2.2 million. Assuming the development trend continues, projecting these costs according to the forecasted amount of impacts could produce an additional $10-$24.5 million in permitting costs and $5-$11 million in compensatory mitigation costs (Figure 28).

	NWPs	IPs	Industry Total
Impacts	153	47	200
Acres	35.40	70.74	106.14
Permit Cost	$3,669,935	$4,102,411	$7,772,346
Mitigation Cost (Low)	$1,471,764	$2,940,750	$4,412,514
Mitigation Cost (High)	$3,964,579	$7,921,676	$11,886,254
Total	$5.1M - $7.6M	$7M – $10.8M	$12.1M - $19.7M

Table 9. Section 404 permit and mitigation costs accrued from 2006-2014.

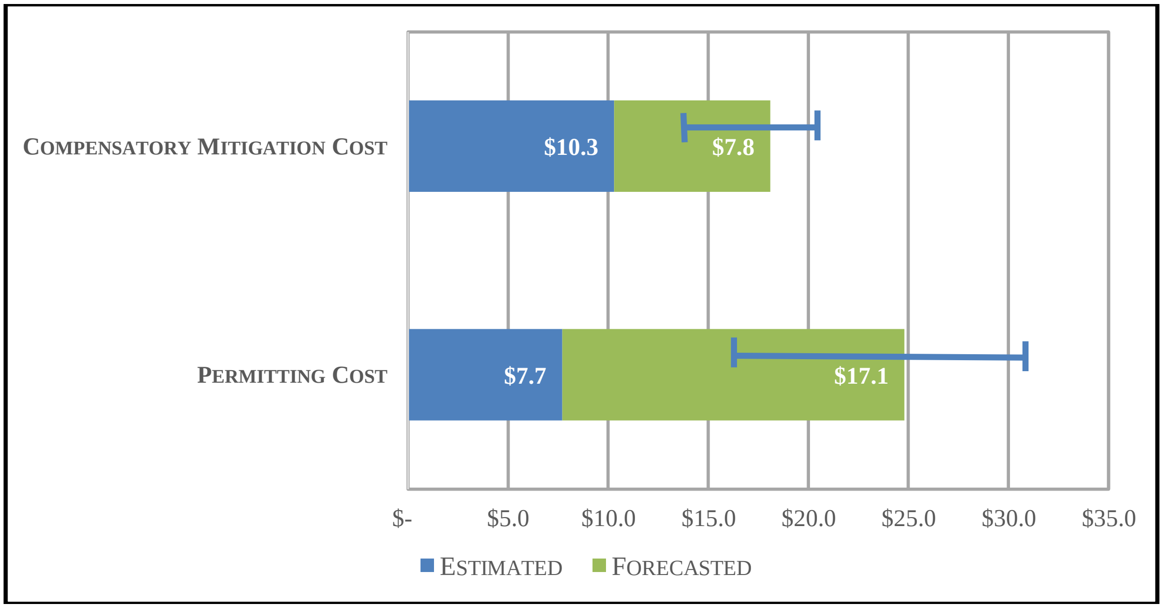

Figure 28. Total estimated economic impact over the estimated and forecasted time frames.

OPERATIONAL IMPACTS

Oil and Gas Operations

Companies engaged in the exploration, development, and production of O&G optimize returns through a disciplined emphasis on controlling costs and promoting operational efficiencies (Jones Energy, 2014). Of all the line items evaluated during the financially intensive E&P process, environmental costs are not always explicitly considered and frequently treated as an externality (Krauss, 2012). They often have the smallest budget, and if it exists, the environmental program is managed entirely by outside consultants. Despite the small fiscal requirement, environmental compliance is a key driver of project timing and success. There are significant risks and liabilities associated with the compliance and enforcement of environmental permits. A Chesapeake Energy Corp. subsidiary agreed to pay nearly $10 million to settle a CWA violation, $3.2 million of which a civil fine, one of the largest levied for damaging wetlands without permits (Snider, 2014).

As E&P continues its trend towards unconventional resources, regions historically absent of production, some containing an increased amount of sensitive environmental resources, are now being developed on a methodical basis (Krauss, 2013). The process of satisfying demand will inevitably result in the construction of well pads, flow lines, gathering systems, access roads, laterals, and transmission and distribution pipelines within and through sensitive areas with unavoidable, permanent environmental impacts (Krauss, 2013). Impact results in this study seem to support the notion that environmental awareness is an integral part of long-term sustainability.

Opportunity Costs

Impacts to regulated resources will necessitate a significant period of time for project planning, environmental review and permit approval in order to meet production timelines, long-term development goals and expected returns on investment. Available historical data regarding the issuance of IPs by the Galveston District of the Corps provides insight to possible delays in project schedules or the time period required for project approval. From January 2013 through October 2015, the Galveston District provided 168 IP records for a wide range of projects containing sufficient data to determine the duration from application finalization to permit issuance. The average duration was 338 days, ranging from a minimum of 33 days to a maximum of 1,387 days, with a median of 256 days. Fifty-three projects required more than 12 months to complete, while 81 were completed in less than 8 months (Figure 29). The distribution of data illustrates a project sponsor can be reasonably confident an IP could be obtained within 12 months of application submittal. However, it is clear a high amount of risk exists for the review period to extend to 18 months or longer depending on project complexity, the extent of impacts and regulatory workload.

Improper planning and project management could result in opportunity costs associated with project capital being tied up in a permitting delay that was unaccounted for. In addition, the data indicates a lack of certainty associated with the permitting schedule. Project management will need to commit a substantial amount of resources in order to expedite the permitting process.

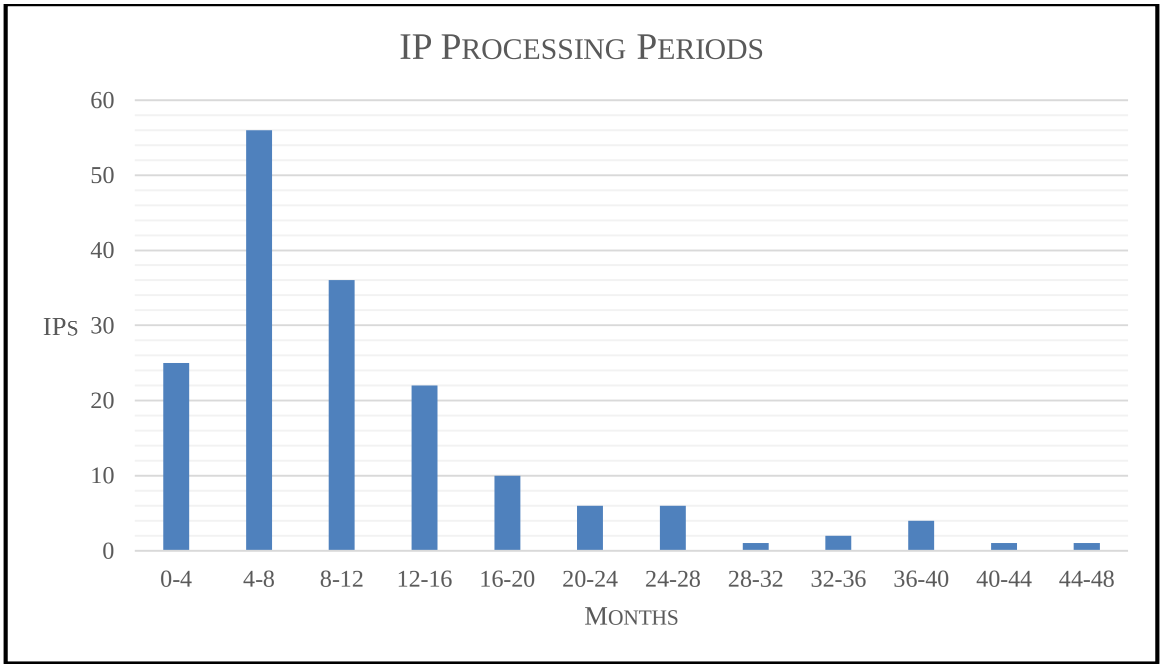

Figure 29. Distribution of USACE Galveston District 2013-2015 IP records by period of permit approval.

Avoidance and Minimization

Given the resources available, it is nearly impossible to make a jurisdictional determination (JD) without the USACE's opinion. In addition, the extent of waters spanning the connectivity continuum requires an intense effort to comprehensively plan with a high level of certainty the proposed layout for well pads, gathering lines, storage facilities, lay-down yards and access roads to avoid the permitting delays. Jurisdictional determinations (JDs) will add additional time to the typical permitting process at an extra cost and investment of company resources. Siting plans will no longer be able to only consider engineering design needs. Figure 30 displays the development of three well pads and associated access roads that possibly avoided all impacts to jurisdictional waters.

Figure 30. Well pads and access roads in the study region using a project layout avoiding impacts to jurisdictional waters.

Permittee Responsible Mitigation (PRM)

Mitigation banks provide operators with a regulatory-endorsed mechanism to reduce permit processing times, operating risk, and in some cases operating costs. Credits representing the compensatory mitigation accompanying section 404 permits may be purchased well in advance of project impacts at known costs (Krauss, 2011). Mitigation bank credits eliminate operator liability for project impacts by transferring the liability to the mitigation bank. This allows a project sponsor to avoid restoration, development and long-term preservation success and also account for mitigation requirements prior to operational activities (Krauss, 2011).

The USACE Regulatory In-Lieu Fee and Bank Information Tracking System (RIBITS) database provides public access to the location of bank sites, bank service areas and available supply. A recent search of the database for mitigation credits in the study region produced no commercial mitigation banks with available credits servicing the watersheds in the region. As a result, compensatory mitigation will have to be conducted by operators themselves under the PRM mechanism. The effects of this include increased financial and regulatory accountability and longer permit evaluation periods. Figure 31 displays data representing permit approval periods by the mechanism of compensatory mitigation (USEPA and USACE, 2015).

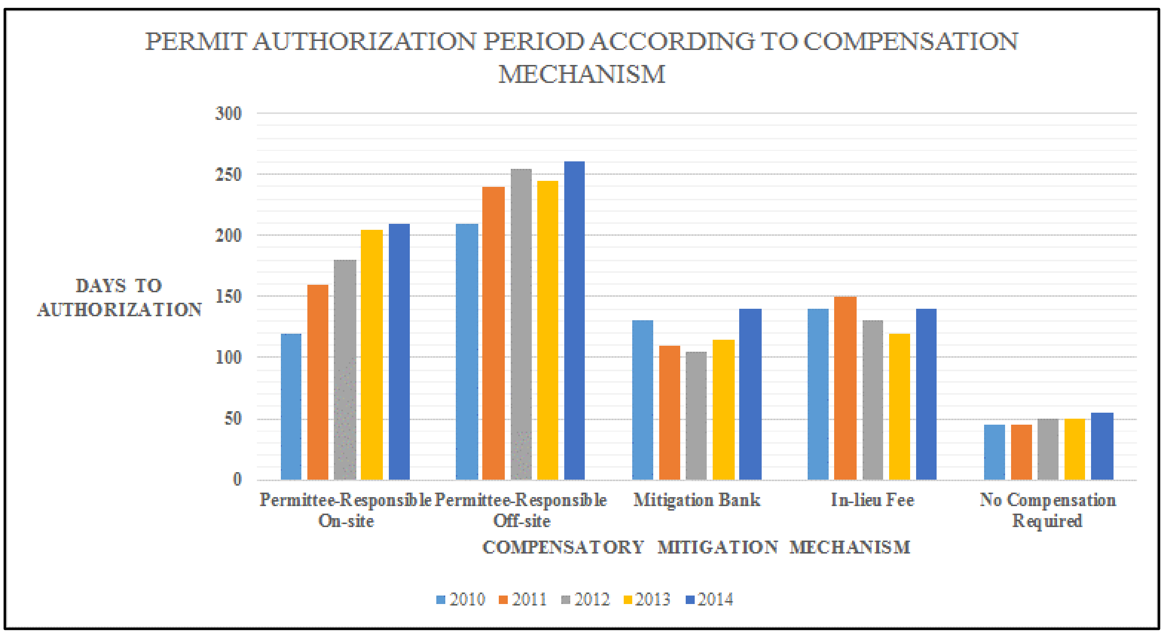

Figure 31. Permit authorization periods according to the mechanism of compensatory mitigation. Modified from a report by the Institute for Water Resources (2015).

From 2010 to 2014 the average time for an authorization was 52 days for activities requiring no compensation. For activities requiring compensatory mitigation, processing times for permit applications were shorter for the use of mitigation bank credits (120 days) or in-lieu fee program credits (136 days). When permittee-responsible mitigation was required, authorization periods averaged 177 days for on-site compensatory mitigation and 243 days for off-site compensatory mitigation (USEPA and USACE, 2015).

Reduced authorization periods are the product of a highly scrutinized instrument approval process. Mitigation banks are developed based on approved mitigation plans, therefore, Corps district engineers only need to determine credit availability and acceptability for the permit requirements. Processing times are longer for PRM plans because the Corps must review each proposed mitigation plan and ensure each of the required plan elements are accounted for (USEPA and USACE, 2015). In addition, the Corps must determine whether the PRM plan is likely to be ecologically successful and sustainable. Permit applications may be denied if the proposed compensatory mitigation is determined to be unfeasible or.

Chapter 5: Conclusions

The 2015 Clean Water Rule was put into effect in order to reduce the jurisdictional scope of the Clean Water Act by clarifying which types of waters are jurisdictional and eliminating most of the demand for the jurisdictional determination process. The practicality of the rule in a "similarly situated" region was analyzed in this study. In addition, the O&G gas industry believes the incorporation of jurisdiction over the prairie pothole waters overlying the Bakken Formation would expand jurisdiction to the point of inflicting economic impacts with the potential to halt production for some operators. The results of this study do not entirely agree with the industry's declarations.

The methodology incorporated in this analysis suggests a substantial increase in jurisdictional extent. The total number of protected waters could potentially increase from 22 percent of all waters in the study region to 91 percent. According to the study region's distribution of individual isolated water acreage, the majority of these waters, if impacted entirely, would necessitate authorization under a NWP.

Given the intensity and unregulated status of isolated waters in the region, the impact trend analysis did not demonstrate a significant economic impact to O&G operations in the region from a Section 404 standpoint. Only 217 impacts were observed from the development of approximately 4,000 wells resulting in an industry wide annual cost of around $2 million. Forecasting development based on the current development trend produces the possible addition of 200-700 impacts over the next decade.

In conclusion, the CWR will increase the total number and surface area of jurisdictional features in the study region. However, an increase in the percentage of jurisdictional waters does not imply a reciprocating economic impact. Instead, the estimated increase in jurisdiction will increase the importance of incorporating environmental awareness into current operations to alleviate inevitable costs associated with delays, mitigation, and compensation, and to ensure industry's long-term sustainability.

Appendices

APPENDIX A – THE REGULATION OF WETLANDS

The permanent degradation or destruction of jurisdictional waters represents a loss of aquatic resource function, among the most severe environmental impacts covered by the CWA. Section 404 of the CWA is established to restore and maintain the chemical, physical, and biological integrity of the Nation's waters by regulating the discharge of dredge and fill material.[33] Such an activity within the defined limits of a regulated aquatic resource is prohibited unless it can be demonstrated it does not have an adverse impact on the function of an aquatic ecosystem in addition to the absence of a practicable alternative.[34]

Dredge and fill activities within jurisdictional waters are regulated by a systematic permit evaluation process implemented by the United States Army Corps of Engineers (USACE). To receive authorization it must be shown, to the maximum extent practicable, steps have been taken to:

1. Avoid impacts to water resources;
2. Minimize impacts to unavoidable water resources; and
3. Provide compensatory mitigation for any remaining unavoidable impacts.

There are two types of Section 404 permits: Individual (IP) and General (GP), also commonly referred to as a Nationwide Permit (NWP). An IP is required when it has been determined the activity will result in impacts over a quantifiable threshold. For activities determined to have minimal impact a GP is issued. GPs exist on a nationwide, regional, state, or programmatic basis for particular categories of activities historically shown to

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33 "Dredged material" is defined as material that has been excavated from WOUS (33 CFR § 323.2 (c)). The discharge of such material, in the context of Section 404, includes: the addition of dredged material to a specific discharge site located in WOUS; the runoff or overflow from a contained land or water disposal area; and any addition, including redeposit other than incidental fallback, of dredged material into a WOUS incidental to any activity (33 CFR § 323.2 (d)). "Fill material" is defined as material placed in WOUS where the material has the effect of: Replacing any portion of a WOUS with dry land; or changing the bottom elevation of any portion of a WOUS (33 CFR §323.2 (e) (1)).

34 33 CFR § 323.2 (f)

have minimal impacts. The GP process is designed to streamline the permit application process by eliminating individual review provided the specific conditions of the GP are met.

A longstanding policy of the CWA regulatory plan is “no net loss” of wetland acreage and function. The “No Net Loss” policy was adopted by the Bush administration in 1989 after being recommended by the National Wetlands Policy Forum in 1987 (MWPF, 1988). The policy is intended to balance economic development with ecological conservation by ensuring wetland area and function impacted or lost through development are replaced by the creation, restoration or enhancement of similar wetland habitats. Compensatory mitigation is a programmatic tool designed to provide ecological offsets to unavoidable adverse impacts to wetlands, streams, and other regulated aquatic resources. Three mechanisms exist that are capable of providing compensatory mitigation:

1. Permittee-Responsible Mitigation;
2. Mitigation Banks;[35] and
3. In-Lieu Fee Mitigation

The agencies have mandated a three-step mitigation sequencing process.[36] In addition, compensatory mitigation plans must be in place before the Corps will consider a permit application. To the maximum extent possible, implementation of the compensatory mitigation project is required to be in advance or concurrent with the impact activity to prevent temporal loss of aquatic function. It is possible, after complying with the sequencing provision, the Corps may determine a 404 permit cannot be issued due to the

[35] A mitigation bank establishes wetlands credits, in advance, to be drawn upon over time. Mitigation credits are generated according to a schedule as defined by the Corps. The bank sponsor sells credits to permittees and keeps a ledger of sales and balances (Krauss, 2013).

[36] 1. Avoid, to extent possible, impacts to regulated resources. 2. Minimize impacts to those resources that cannot be avoided. 3. Mitigate impacts to those resources that cannot be further minimized (33 CFR § 332.1 (c).

lack of sufficient and practicable compensatory mitigation options. Considerations that the Corps will take into account when determining the compensatory mitigation required for a particular 404 permit include:

- What is practicable and capable of offsetting the ecological functions that will be lost as a result of the project;
- What is environmentally preferable among the available options;
- The likelihood for ecological success and sustainability;
- The location of the compensation relative to the impact site;
- Significance of the impacts within the watershed; and
- The cost of the compensatory mitigation project.

The Corps would prefer compensatory mitigation be located within the same watershed as the impact site as well as in a location where it is most likely to replace lost ecological function. This "watershed approach" is conducive to the goal to maintain and improve the quality and quantity of aquatic resources within watersheds through strategic site selection by considering the type of aquatic resource function, habitat requirements of important species, trends in habitat conversion and loss, sources of watershed impairment, and current development trends.[37]

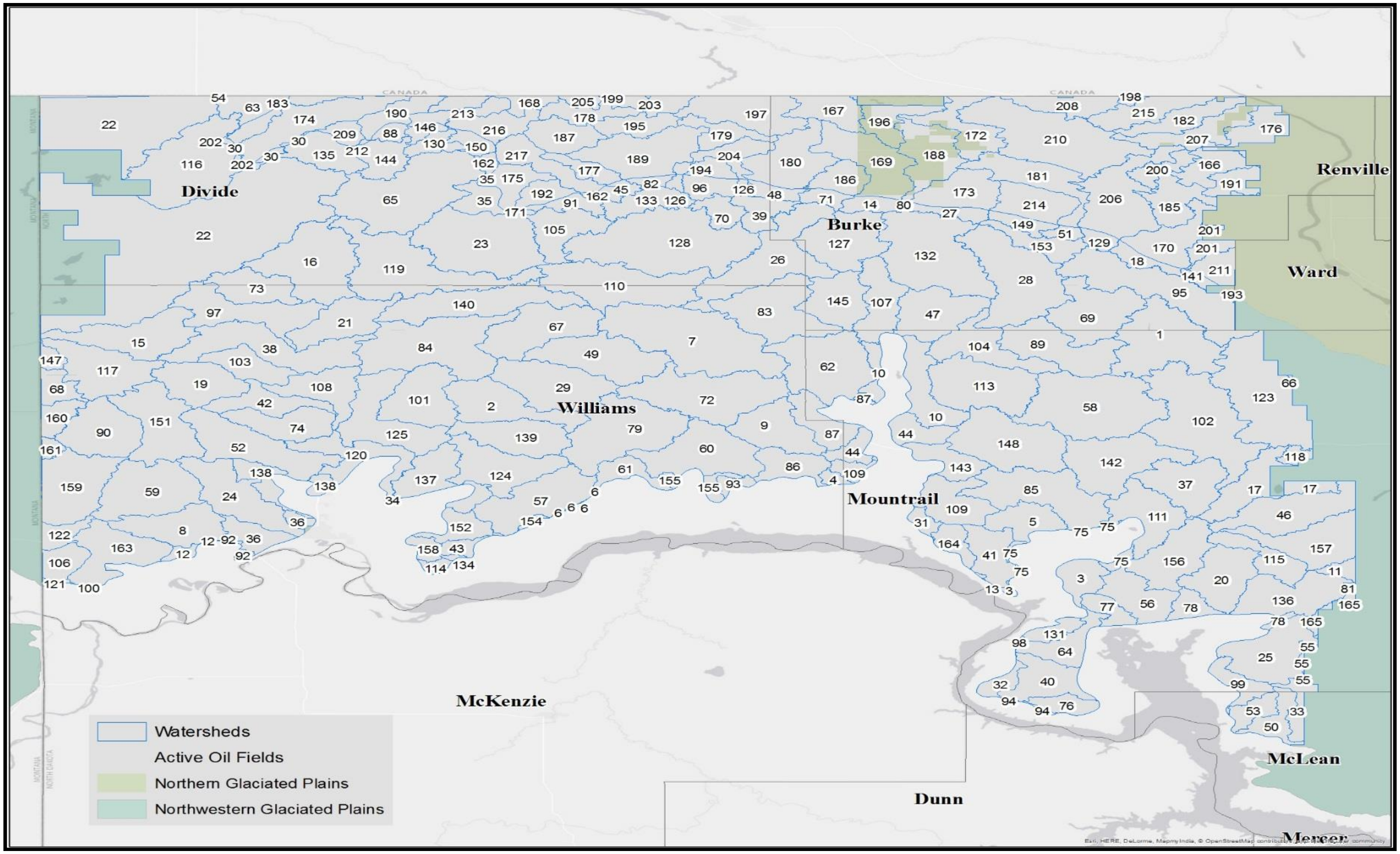
In 2008, the agencies promulgated the Final Rule governing Compensatory Mitigation for Losses of Aquatic Resources (33 CFR Parts 332). The rule established mitigation banks as the preferred mitigation mechanism in any given watershed citing its proven reputation for responsibility. The use of a mitigation bank reduces uncertainty and risk associated with mitigation success as well as the prevention of temporal loss of aquatic

[37] 33 CFR § 332.3 (b) (1)

functions within a watershed.[38]The amount of compensatory mitigation required must be sufficient to replace lost aquatic resource functions. Functional and conditional assessment methods are available by region to determine the amount of mitigation required for impacts to particular aquatic resource types. If functional or conditional assessment methods are not available, a minimum one-to-one acreage or linear foot ratio must be used to accomplish the “no net loss” goal. In general, the Corps requires ratios greater than 1 to 1 to account for the mitigation method, likelihood of success, the distance from the impact site, temporal loss of aquatic function, and the differences between the functions lost at the impact site and the functions expected to generate from the compensatory mitigation project.[39]

[38] 33 CFR § 332.3 (b) (2)
[39] 33 CFR § 332.3 (f)

APPENDIX B – ISOLATED WATER EXTENT BY WATERSHED



Watershed IDs

Map ID	HUC12	HUC Acres	All Waters (Number)	All Waters (Acres)	Percent Wetlands (All)	Isolated Waters (Number)	Isolated Waters (Acres)	Percent Isolated (Number)	Percent Isolated (Area)
1	101101011601	34037	3529	3879	11.40%	3450	3738	11%	106%
2	101101020402	21900	301	422	1.93%	172	324	2%	108%
3	101101011708	22721	263	147	0.65%	196	119	1%	45%
4	101101011005	19713	105	66	0.33%	84	49	0%	46%
5	101101011705	15996	377	197	1.23%	285	168	1%	44%
6	101101010705	10947	12	5	0.04%	10	2	0%	19%
7	101101011102	50038	1482	2614	5.22%	1159	1296	5%	87%
8	101101010202	18628	399	193	1.04%	179	59	1%	15%
9	101101011402	18421	256	201	1.09%	175	166	1%	65%
10	101101011308	32311	766	740	2.29%	718	706	2%	92%
11	101101012401	23216	260	120	0.52%	235	105	1%	40%
12	101101010203	14589	22	7	0.05%	5	1	0%	3%
13	101101011804	11164	0	0	0.00%	0	0	0%	0%
14	90100071102	27604	444	486	1.76%	432	482	2%	109%
15	100600061301	24087	331	290	1.20%	204	185	1%	56%
16	101101020102	33879	1079	1806	5.33%	993	1456	5%	135%
17	101101012302	25686	2177	1385	5.39%	2146	1369	5%	63%
18	90100020202	21990	559	488	2.22%	559	488	2%	87%
19	101101020303	17447	314	119	0.68%	62	43	1%	14%
20	101101012404	19484	837	770	3.95%	680	497	4%	59%
21	101101020206	17693	336	528	2.98%	267	379	3%	113%
22	100600070002	630445	8739	10840	1.72%	8334	9696	2%	111%
23	90100060502	40408	2077	2969	7.35%	2045	2851	7%	137%
24	101101010302	23620	442	206	0.87%	238	102	1%	23%
25	101101012605	28056	842	842	3.00%	580	401	3%	48%
26	101101011202	33661	2753	3143	9.34%	2571	2593	9%	94%

Map ID	HUC12	HUC Acres	All Waters (Number)	All Waters (Acres)	Percent Wetlands (All)	Isolated Waters (Number)	Isolated Waters (Acres)	Percent Isolated (Number)	Percent Isolated (Area)
27	90100071203	20430	550	408	2.00%	499	375	2%	68%
28	101101011304	37204	3122	3203	8.61%	2922	2852	9%	91%
29	101101020201	26330	615	422	1.60%	446	328	2%	53%
30	90100060705	27234	113	61	0.22%	113	61	0%	54%
31	101101011505	14131	268	221	1.56%	268	221	2%	82%
32	101101012005	19012	51	31	0.16%	38	20	0%	39%
33	101101012807	12333	310	208	1.69%	232	154	2%	50%
34	101101010405	8434	0	0	0.00%	0	0	0%	0%
35	90100060505	17486	1028	291	1.67%	1026	279	2%	27%
36	101101010303	26314	92	65	0.25%	48	27	0%	29%
37	101101011703	19687	2021	1880	9.55%	1984	1773	10%	88%
38	101101020301	30770	440	479	1.56%	215	193	2%	44%
39	90100060606	8664	416	1021	11.78%	370	874	12%	210%
40	101101012704	19888	137	171	0.86%	78	112	1%	82%
41	101101011707	13595	482	395	2.90%	312	268	3%	56%
42	101101020304	12118	182	58	0.48%	42	14	0%	8%
43	101101010703	13117	48	28	0.22%	17	7	0%	16%
44	101101011502	19181	472	587	3.06%	422	454	3%	96%
45	90100060603	7896	139	128	1.62%	139	128	2%	92%
46	101101012303	29258	1586	1429	4.89%	1371	855	5%	54%
47	101101011306	20479	795	1947	9.51%	611	502	10%	63%
48	90100071103	25436	271	272	1.07%	259	252	1%	93%
49	101101020202	26348	611	363	1.38%	325	260	1%	43%
50	101101012810	21750	318	356	1.64%	248	287	2%	90%
51	90100071204	20644	175	225	1.09%	162	211	1%	120%
52	101101020504	27921	627	296	1.06%	159	86	1%	14%

Map ID	HUC12	HUC Acres	All Waters (Number)	All Waters (Acres)	Percent Wetlands (All)	Isolated Waters (Number)	Isolated Waters (Acres)	Percent Isolated (Number)	Percent Isolated (Area)
53	101101012901	26109	275	164	0.63%	215	118	1%	43%
54	90100060701	16622	2	0	0.00%	2	0	0%	10%
55	101101012604	10182	21	23	0.22%	13	6	0%	27%
56	101101012702	15936	424	408	2.56%	274	241	3%	57%
57	101101010401	25267	493	315	1.25%	322	185	1%	38%
58	101101011602	43891	1602	1364	3.11%	1386	1139	3%	71%
59	101101010201	28708	741	342	1.19%	466	200	1%	27%
60	101101010903	27732	619	474	1.71%	492	339	2%	55%
61	101101010901	20373	188	85	0.42%	150	52	0%	28%
62	101101011403	32763	912	767	2.34%	723	588	2%	64%
63	90100060703	24394	715	656	2.69%	709	625	3%	87%
64	101101012703	13553	185	310	2.29%	116	97	2%	53%
65	90100060501	45627	2065	3472	7.61%	1962	3206	8%	155%
66	101101011605	23486	36	48	0.21%	36	48	0%	135%
67	101101020203	24781	733	580	2.34%	522	470	2%	64%
68	100600061303	17215	194	123	0.72%	169	95	1%	49%
69	101101011302	24142	1750	1781	7.38%	1725	1752	7%	100%
70	90100060605	6497	362	609	9.37%	340	553	9%	153%
71	90100071101	12579	374	377	3.00%	371	371	3%	99%
72	101101011401	35413	1434	2109	5.96%	1365	1939	6%	135%
73	101101020103	13828	273	338	2.44%	178	290	2%	106%
74	101101020501	15450	309	124	0.80%	63	40	1%	13%
75	101101011706	21303	183	123	0.58%	181	120	1%	66%
76	101101012104	15213	157	50	0.33%	35	14	0%	9%
77	101101012705	30168	67	87	0.29%	31	25	0%	37%

Map ID	HUC12	HUC Acres	All Waters (Number)	All Waters (Acres)	Percent Wetlands (All)	Isolated Waters (Number)	Isolated Waters (Acres)	Percent Isolated (Number)	Percent Isolated (Area)
78	101101012405	21770	164	91	0.42%	95	50	0%	30%
79	101101010902	34733	1123	1043	3.00%	924	727	3%	65%
80	90100071206	19127	13	7	0.04%	12	7	0%	53%
81	101101012602	32409	134	68	0.21%	131	65	0%	49%
82	90100060610	27753	150	116	0.42%	150	116	0%	77%
83	101101011203	28372	1275	856	3.02%	1061	624	3%	49%
84	101101020204	39773	1453	1198	3.01%	1288	971	3%	67%
85	101101011701	30180	2002	1717	5.69%	1832	1477	6%	74%
86	101101010904	16573	309	106	0.64%	169	64	1%	21%
87	101101011404	17923	146	102	0.57%	94	73	1%	50%
88	90100060706	22987	175	179	0.78%	167	159	1%	91%
89	101101011303	23679	956	911	3.85%	700	504	4%	53%
90	101101020502	21498	821	413	1.92%	495	258	2%	31%
91	90100060504	11245	216	266	2.37%	210	262	2%	121%
92	101101010301	11864	8	4	0.03%	5	3	0%	34%
93	101101010905	16133	60	26	0.16%	38	14	0%	24%
94	101101012103	28459	1	0	0.00%	1	0	0%	27%
95	90100020201	39415	3259	4343	11.02%	3150	4086	11%	125%
96	90100060607	10730	356	380	3.54%	331	353	4%	99%
97	101101020104	23704	267	1117	4.71%	122	129	5%	48%
98	101101012002	10988	13	3	0.02%	12	2	0%	19%
99	101101012706	37152	142	119	0.32%	91	100	0%	70%
100	101101010101	29871	0	0	0.00%	0	0	0%	0%
101	101101020403	21047	363	324	1.54%	204	172	2%	47%
102	101101011603	45150	3084	2718	6.02%	3013	2504	6%	81%
103	101101020302	11615	244	70	0.60%	29	12	1%	5%

Map ID	HUC12	HUC Acres	All Waters (Number)	All Waters (Acres)	Percent Wetlands (All)	Isolated Waters (Number)	Isolated Waters (Acres)	Percent Isolated (Number)	Percent Isolated (Area)
104	101101011305	18556	384	333	1.79%	245	171	2%	45%
105	90100060503	15182	929	1124	7.40%	906	1098	7%	118%
106	100600050703	16018	79	48	0.30%	20	9	0%	11%
107	101101011205	16726	968	1142	6.83%	828	760	7%	78%
108	101101020305	15556	230	223	1.43%	112	78	1%	34%
109	101101011504	31257	1300	1483	4.75%	1252	1344	5%	103%
110	101101011103	32781	1202	5373	16.39%	1160	2477	16%	206%
111	101101011704	21265	1389	1378	6.48%	1315	948	6%	68%
112	90100020401	15591	30	25	0.16%	30	25	0%	83%
113	101101011307	28524	871	799	2.80%	769	617	3%	71%
114	101101010603	7337	15	13	0.17%	3	1	0%	9%
115	101101012402	11641	723	480	4.12%	483	298	4%	41%
116	100600070001	41576	1499	2046	4.92%	1409	1657	5%	111%
117	100600061302	23345	554	242	1.04%	176	85	1%	15%
118	101101012301	23503	362	213	0.91%	362	213	1%	59%
119	101101020101	40703	1376	2746	6.75%	1352	2613	7%	190%
120	101101020505	25016	262	362	1.45%	112	62	1%	24%
121	100600050905	39277	4	3	0.01%	2	2	0%	58%
122	100600050704	25446	54	16	0.06%	9	3	0%	6%
123	101101011604	54706	2461	2998	5.48%	2341	2666	5%	108%
124	101101010402	22239	451	418	1.88%	253	114	2%	25%
125	101101020404	26055	350	304	1.17%	185	98	1%	28%
126	90100060608	11808	225	142	1.21%	218	138	1%	61%

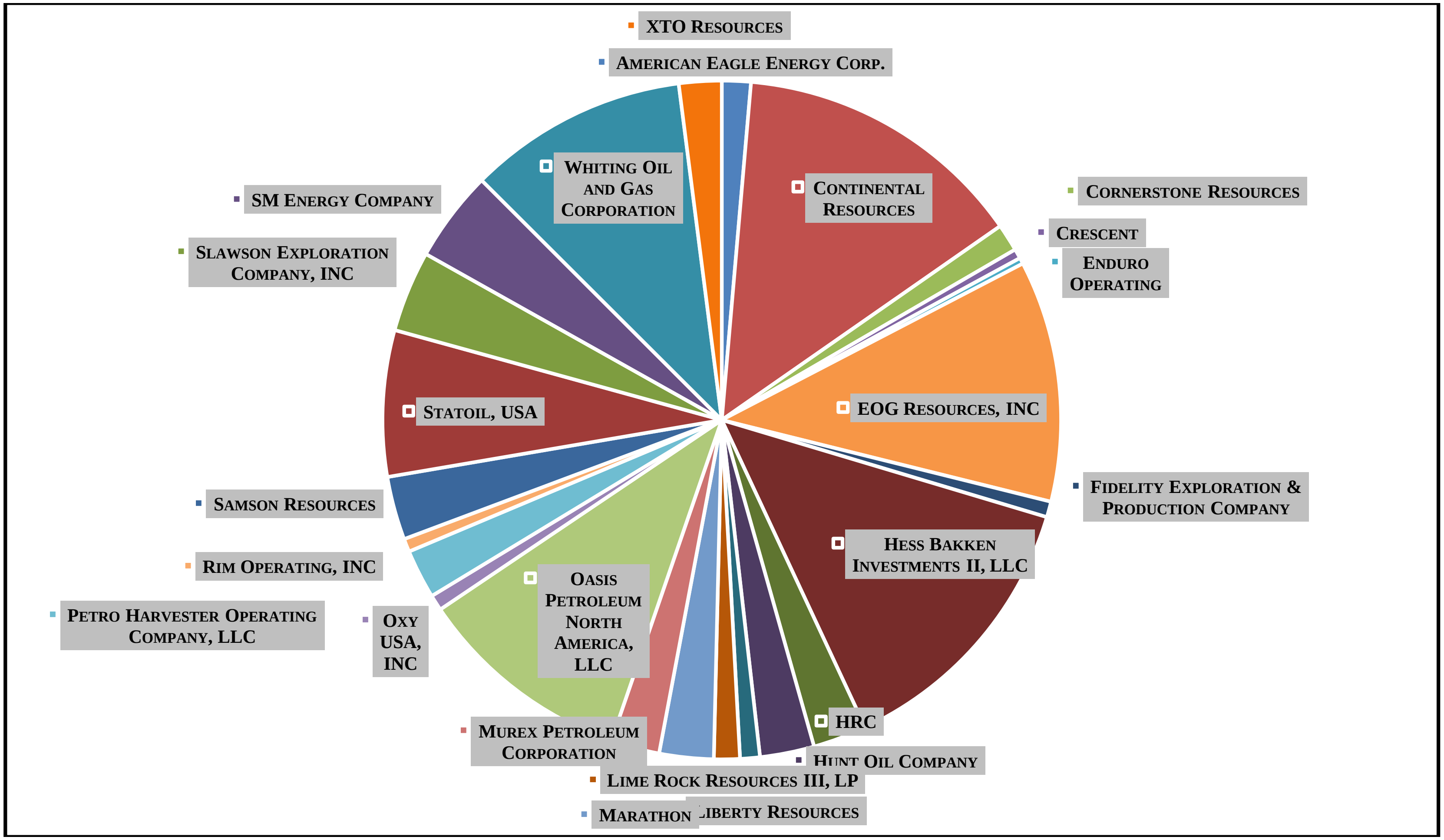
Map ID	HUC12	HUC Acres	All Waters (Number)	All Waters (Acres)	Percent Wetlands (All)	Isolated Waters (Number)	Isolated Waters (Acres)	Percent Isolated (Number)	Percent Isolated (Area)
127	101101011201	23129	3239	3270	14.14%	3218	3172	14%	98%
128	101101011101	53289	3073	4698	8.82%	2932	4270	9%	139%
129	90100020103	31241	250	326	1.04%	246	314	1%	126%
130	90100060710	5177	345	579	11.18%	345	579	11%	168%
131	101101012001	17395	67	89	0.51%	43	39	1%	58%
132	101101011301	41424	4209	5200	12.55%	4053	4995	13%	119%
133	90100060601	9859	617	923	9.36%	602	899	9%	146%
134	101101010605	30232	1	1	0.00%	1	1	0%	87%
135	90100060704	17074	818	1020	5.98%	786	971	6%	119%
136	101101012403	23421	1075	481	2.05%	834	351	2%	33%
137	101101010403	23034	287	215	0.93%	177	108	1%	38%
138	101101020506	29928	219	85	0.28%	107	25	0%	12%
139	101101020401	19144	220	87	0.45%	101	40	0%	18%
140	101101020205	27130	712	1244	4.58%	623	824	5%	116%
141	90100020402	25048	182	174	0.70%	182	174	1%	96%
142	101101011702	28387	1439	2073	7.30%	1314	1180	7%	82%
143	101101011503	16466	377	285	1.73%	320	245	2%	65%
144	90100060708	10045	563	1006	10.01%	556	989	10%	176%
145	101101011204	16706	661	387	2.32%	447	244	2%	37%
146	90100060709	9534	158	222	2.32%	153	204	2%	129%
147	100600061304	22237	19	4	0.02%	13	3	0%	14%
148	101101011501	31184	1412	1706	5.47%	1302	1357	5%	96%
149	90100071202	18801	443	419	2.23%	434	415	2%	94%
150	90100060711	14703	390	234	1.59%	390	234	2%	60%
151	101101020503	26203	767	342	1.31%	432	201	1%	26%
152	101101010404	14936	107	48	0.32%	26	14	0%	13%

Map ID	HUC12	HUC Acres	All Waters (Number)	All Waters (Acres)	Percent Wetlands (All)	Isolated Waters (Number)	Isolated Waters (Acres)	Percent Isolated (Number)	Percent Isolated (Area)
153	90100071201	9317	1024	1416	15.20%	953	1322	15%	129%
154	101101010704	8224	10	5	0.06%	4	3	0%	30%
155	101101010906	13325	88	74	0.55%	62	38	1%	43%
156	101101012701	20583	1584	1589	7.72%	1479	1416	8%	89%
157	101101012304	25735	1195	1133	4.40%	935	546	4%	46%
158	101101010601	8506	35	20	0.23%	4	3	0%	9%
159	100600050701	32685	627	338	1.03%	355	190	1%	30%
160	100600061202	14091	169	198	1.41%	149	103	1%	61%
161	100600061203	31930	8	6	0.02%	3	2	0%	28%
162	90100060602	16053	223	297	1.85%	216	296	2%	133%
163	101101010102	27843	268	129	0.46%	81	20	0%	8%
164	101101011801	27295	407	288	1.05%	356	245	1%	60%
165	101101012603	10167	209	100	0.98%	204	97	1%	46%
166	90100020304	17651	1052	695	3.94%	971	604	4%	57%
167	90100071104	12258	606	737	6.02%	589	725	6%	120%
168	90100060712	24946	458	384	1.54%	448	239	2%	52%
169	90100071102	27604	351	318	1.15%	294	297	1%	85%
170	90100020202	21990	448	783	3.56%	288	269	4%	60%
171	90100060502	40408	0	0	0.00%	0	0	0%	0%
172	90100071205	16271	709	1412	8.68%	644	924	9%	130%
173	90100071203	20430	255	556	2.72%	122	190	3%	74%
174	90100060705	27234	2396	1149	4.22%	2287	1025	4%	43%
175	90100060505	17486	174	205	1.17%	137	129	1%	74%
176	90100020305	23942	1115	360	1.50%	1081	343	2%	31%
177	90100060603	7896	276	152	1.92%	268	145	2%	53%

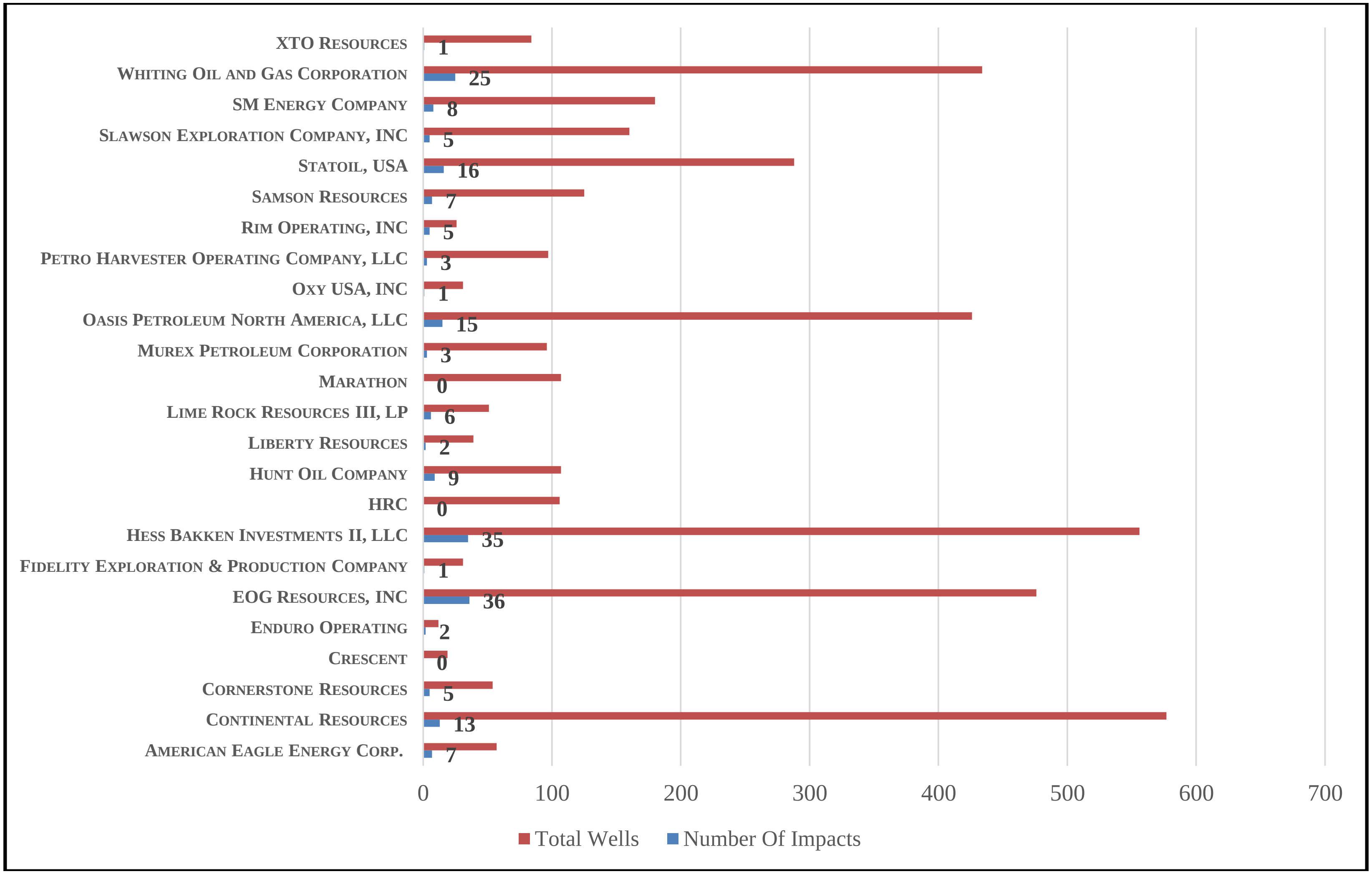
Map ID	HUC12	HUC Acres	All Waters (Number)	All Waters (Acres)	Percent Wetlands (All)	Isolated Waters (Number)	Isolated Waters (Acres)	Percent Isolated (Number)	Percent Isolated (Area)
178	90100060713	8368	449	237	2.83%	425	218	3%	49%
179	90100060609	8461	286	642	7.59%	261	314	8%	110%
180	90100071103	25436	974	1054	4.14%	632	467	4%	48%
181	90100071204	20644	916	3004	14.55%	789	1624	15%	177%
182	90100020302	11457	1021	658	5.74%	881	588	6%	58%
183	90100060703	24394	489	436	1.79%	483	365	2%	75%
184	90100060501	45627	0	0	0.00%	0	0	0%	0%
185	90100020203	24387	682	1559	6.39%	634	1248	6%	183%
186	90100071101	12579	247	255	2.02%	138	121	2%	49%
187	90100060604	11836	1194	812	6.86%	1194	812	7%	68%
188	90100071206	19127	299	421	2.20%	259	287	2%	96%
189	90100060610	27753	1013	1456	5.25%	908	928	5%	92%
190	90100060706	22987	541	273	1.19%	465	228	1%	42%
191	90100020306	15924	1138	550	3.46%	1126	521	3%	46%
192	90100060504	11245	223	273	2.43%	201	162	2%	73%
193	90100020201	39415	1	0	0.00%	1	0	0%	21%
194	90100060607	10730	96	125	1.17%	72	96	1%	100%
195	90100060611	8796	526	537	6.11%	515	530	6%	101%
196	90100071207	32165	239	334	1.04%	194	267	1%	112%
197	90100071309	23250	939	1596	6.87%	939	1596	7%	170%
198	90100020303	12269	97	24	0.20%	97	24	0%	25%
199	90100060802	19562	7	12	0.06%	7	12	0%	169%
200	90100020102	6192	428	939	15.16%	383	752	15%	176%
201	90100020401	15591	131	223	1.43%	100	75	1%	57%
202	100600070001	41576	32	16	0.04%	32	16	0%	51%

Map ID	HUC12	HUC Acres	All Waters (Number)	All Waters (Acres)	Percent Wetlands (All)	Isolated Waters (Number)	Isolated Waters (Acres)	Percent Isolated (Number)	Percent Isolated (Area)
203	90100060803	20607	182	180	0.87%	158	118	1%	65%
204	90100060608	11808	306	824	6.98%	191	272	7%	89%
205	90100060801	28262	128	142	0.50%	128	142	1%	111%
206	90100020103	31241	1085	4612	14.76%	888	2808	15%	259%
207	90100020104	14499	1166	745	5.14%	1125	635	5%	55%
208	90100080805	20200	1602	692	3.43%	1586	676	3%	42%
209	90100060704	17074	224	397	2.32%	208	259	2%	116%
210	90100020101	43477	3302	5487	12.62%	3165	4304	13%	130%
211	90100020402	25048	96	242	0.97%	80	83	1%	86%
212	90100060708	10045	20	22	0.22%	20	22	0%	111%
213	90100060709	9534	332	117	1.22%	247	89	1%	27%
214	90100071202	18801	382	732	3.89%	158	153	4%	40%
215	90100020301	16017	1272	890	5.55%	1202	779	6%	61%
216	90100060711	14703	475	423	2.88%	413	200	3%	42%
217	90100060602	16053	486	474	2.95%	434	249	3%	51%

APPENDIX C – OPERATOR IMPACT DATA



Proportion of the total wells in the study by operator.


XTO Resources
Whiting Oil and Gas Corporation
SM Energy Company
Slawson Exploration Company, INC
Statoil, USA
Samson Resources
Rim Operating, INC
Petro Harvester Operating Company, LLC
Oxy USA, INC
Oasis Petroleum North America, LLC
Murex Petroleum Corporation
Marathon
Lime Rock Resources III, LP
Liberty Resources
Hunt Oil Company
HRC
Hess Bakken Investments II, LLC
Fidelity Exploration & Production Company
EOG Resources, INC
Enduro Operating
Crescent
Cornerstone Resources
Continental Resources
American Eagle Energy Corp.
1
25
8
5
16
7
5
3
1
15
3
0
6
2
9
0
35
1
36
2
0
5
13
7
0
100
200
300
400
500
600
700
Total Wells
Number Of Impacts

Operator	Number Of Impacts	Impacts in High Density	Impacts in Low Density	Total Wells	Wells in High Density	Wells in Low Density
American Eagle Energy Corp.	7	4	3	57	45	12
Continental Resources	13	10	3	577	260	317
Cornerstone Resources	5	5	0	54	35	19
Crescent	0	0	0	19	5	14
Enduro Operating	2	2	0	12	7	5
EOG Resources, INC	36	22	14	476	209	267
Fidelity Exploration & Production Company	1	1	0	31	8	23
Hess Bakken Investments II, LLC	35	29	6	556	194	362
HRC	0	0	0	106	6	100
Hunt Oil Company	9	9	0	107	55	52
Liberty Resources	2	1	1	39	25	14
Lime Rock Resources III, LP	6	5	1	51	30	21
Marathon	0	0	0	107	3	104
Murex Petroleum Corporation	3	3	0	96	53	43
Oasis Petroleum North America, LLC	15	5	10	426	119	307
Oxy USA, INC	1	1	0	31	22	9
Petro Harvester Operating Company, LLC	3	3	0	97	26	71
Rim Operating, INC	5	5	0	26	19	7
Samson Resources	7	6	1	125	88	37
Statoil, USA	16	11	5	288	119	169
Slawson Exploration Company, INC	5	1	4	160	17	143
SM Energy Company	8	8	0	180	124	56
Whiting Oil and Gas Corporation	25	14	11	434	115	319
XTO Resources	1	1	0	84	43	41

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